OPERATION AND MAINTENANCE MANUAL

PRESSURE TRANSFER STANDARD

MODEL PTS-102

JUNE 1978 DOCUMENT NO. M2415

METROLOGY GENERAL CORPORATION
8957 COMPLEX DRIVE, SAN DIEGO, CALIFORNIA 92123
PHONE: 714-560-0393

OPERATION AND MAINTENANCE MANUAL

PRESSURE TRANSFER STANDARD

MODEL PTS-102

JUNE 1978 DOCUMENT NO. M2415

METROLOGY GENERAL CORPORATION
8957 COMPLEX DRIVE, SAN DIEGO, CALIFORNIA 92123 PHONE: 714-560-0393

Copyright© 1978.
Contents of this publication may
not be reproduced in any form in
whole or part without permission
of Metrology General Corporation.
All rights reserved.

Published by the Publications Department
Metrology General Corporation

The operations and maintenance manual should be consulted before putting this equipment into service. If you have questions regarding its installation or use, please call our customer service department.

8957 Complex Drive, San Diego, California 92123 (714) 560-0393

WARRANTY

Metrology General Corporation warrants each new product manufactured by us to be free from defects in workmanship or material under normal use and service.

Our obligation under this warranty is limited to replacing by our factory, any part or parts thereof which shall, within one (1) year from date of purchase by original consumer, upon our examination prove to have been defective.

WHAT THIS WARRANTY DOES NOT INCLUDE --- This warranty shall not apply to any product, manufactured by Metrology General Corporation, which has been repaired or altered outside of our authorized service organization which, in our judgement, affects its condition or operation. Neither is it effective if the product has been subject to misuse, negligence, or accident.

Metrology General Corporation reserves the right to make changes, additions, deletions, or improvements upon its products with no obligation to install same upon its product theretofore manufactured.

METROLOGY GENERAL CORPORATION

THIS PLAGE LEFT BLANK

TABLE OF CONTENTS

		PAGE
SECTION I	GENERAL INFORMATION	1-1
1.1	Introduction	1-1
1.2	Instrument Description	1-1
1.3	Reference Data	1-5
SECTION II	OPERATION	2-1
2.1	Introduction	2-1
2.2	Safety Precautions	2-1
2.3	Operator Controls	2-2
2.4	Indicators	2-4
2.5	Operating Modes	2-4
2.6	Operation	2-5
2.7	Data Acquisition	2-8
2.8	Data and Logic Errors	2-14
SECTION III	THEORY OF OPERATION	3-1
3.1	Introduction	3-1
3.2	Theory of Pressure Detection and Measurement	3-1
3.3	Pressure Transducer	3-3
3.4	Capacitance Controlled Oscillator	3-5
3.5	Period Counter Assembly	3-7
3.6	CPU Assembly	3-9
3.7	GPIB Assembly	3-11
3.8	Display I/O and Display Assembly	3-12
3.9	Power Supply	3-14
SECTION IV	MAINTENANCE	4-1
4.1	Introduction	4-1
4.2	Qualifiers	4-1
4.3	Cautions	4-1
4.4	Test Equipment and Tools	4-2
4.5	Scheduled Maintenance	4-3
4.6	Troubleshooting and Fault Isolation	4-4
4.7	Disassembly and Assembly	4-10
4.8	Cleaning	4-12
4.9	Recalibration Adjustments	4-13
4.10	Look Up Table	4-18
4.11	LUT Generation and Modification	4-19
4.12	PROM Programming	4-23
SECTION V	ILLUSTRATED PARTS LIST	5-1
5.1	Introduction	5-1
5.2	Parts List Format	5-1
5.3	Ordering Information	5-1
5.4	FSCM Code Number to Manufacturer's Name	5-1
5.5	Recommended Spare Parts	5-2
5.6	Illustrated Parts Lists	5-5
SECTION VI	DOCUMENTATION	6-1
6.1	Introduction	6-1
6.2	List of Documents	6-1

LIST OF ILLUSTRATIONS

FIGURE	TITLE	PAGE
1-1	Pressure Transfer Standard Model PTS-102	viii
2-1	Operator Controls and Indicators	2-4
2-2	Test Configuration	2-6
2-3	Data Word Format	2-9
2-4	Sample GPIB Program	2-9
3-1	Available Functions of Period Counter	3-9
3-2	Available Functions of GPIB I/O	3-13
3-3	Available Functions of Display I/O	3-15
3-4	Period Counter Block Diagram	3-7
3-5	Counter Control Sequence Timing	3-8
3-6	CPU Block Diagram	3-10
3-7	GPIB I/O Block Diagram	3-11
3-8	Display I/O Block Diagram	3-14
4-1	Test Configuration	4-14
4-2	Temperature Compensation Test Configuration	4-16
4-3	LUT Organization	4-19
5-1	Front View of Model PTS-102 with Case Removed	5-12
5-2	Rear View of Model PTS-102	5-13
5-3	Bottom View of Model PTS-102	5-13
5-4	PWA, Capacitance Controlled Oscillator	5-14
5-5	PWA, Period Counter	5-15
5-6	PWA, CPU	5-16
5-7	PWA, GPIB I/O	5-17
5-8	PWA, Display I/O	5-18
5-9	PWA, Power Supply	5-19
5-10	PWA, Display Driver	5-20
5-11	Single Port Blocking Valve	5-20
6-1	CCO Schematic	6-2
6-2	Period Counter Schematic	6-3
6-3	CPU Schematic	6-4
6-4	GPIB Schematic	6-5
6-5	Display I/O Schematic	6-6
6-6	Power Supply Schematic	6-7
6-7	Display Driver Schematic	6-8
6-8	System Interconnect	6-9
6-9	System Flow Chart	6-10

LIST OF TABLES

TABLE	DESCRIPTION	PAGE
1-1	Equipment and Documentation Supplied	1-1
1-2	Capabilities	1-2
1-3	Limitations	1-2
1-4	Modules and Assemblies	1-4
1-5	Optional System Support Equipment not Supplied	1-4
1-6	Functional Specifications	1-5
1-7	Descriptive Nameplate Data	1-6
2-1	Operator Responsibilities	2-1
2-2	Table of Controls and Indicators	2-3

LIST OF TABLES

TABLE	DESCRIPTION	PAGE
2-3	Pressure Change Rates for Optimum Accuracy	2-7
2-4	GPIB Line Functions	2-8
2-5	Capabilities	2-9
2-6	Device Dependent Codes	2-9
2-7	ASCII Code Transmission	2-10
2-8	Bus Commands	2-11
2-9	Allowable Address Codes	2-12
2-10	Diagnostic Error Codes	2-14
3-1	Available Functions of Period Counter	3-9
3-2	Available Functions of GPIB I/O	3-13
3-3	Available Functions of Display I/O	3-15
4-1	Test Equipment and Tools	4-2
4-2	Scheduled Maintenance	4-3
4-3	Troubleshooting Guide	4-6 thru 4-9
4-4	Error Code Listing	4-10
4-5	LUT Address	4-21
4-6	Number Conversion	4-25
5-1	FSCM Code to Name Conversion	5-2
5-2	Level 1 Recommended Spare Parts	5-3
5-3	Level 2 Recommended Spare Parts	5-3
5-4	Level 3 Recommended Spare Parts	5-4
5-5	Pressure Transfer Standard	5-5
5-6	Assembly-Pressure Transducer 10K PSIG	5-6
5-7	Assembly-Pressure Transducer 1K PSIG	5-6
5-8	PWA, Capacitance Controlled Oscillator	5-6
5-9	PWA, Period Counter	5-8
5-10	PWA, CPU	5-8
5-11	PWA, GPIB I/O	5-9
5-12	PWA, Display I/O	5-10
5-13	PWA, Power Supply	5-11
5-14	PWA, Interconnect Board	5-11
5-15	PWA, Display Driver	5-11
6-1	Memory Map of Program & I/O	6-11
6-2	Microprocessor Program	6-12 thru 6-23

Figure 1-1 Pressure Transfer Standard Model PTS-102 System

SECTION I
GENERAL INFORMATION

1.1 INTRODUCTION The Pressure Transfer Standard Model PTS-102 (Figure 1-1) made by Metrology General Corporation, is a portable instrument used for making precise measurements of hydraulic or pneumatic pressure. The instrument is designed for use as a pressure transfer standard in calibration of other pressure measuring systems. The precise nature of the pressure measurement enables the Model PTS-102 to replace a precision dead weight piston gauge in applications where an alternate pressure source is available. The instrument enables comparisons and calibrations to be performed without the need for a precisely controlled pressure source.

The Model PTS-102 is a portable instrument that may be operated at any angle or elevation. A laboratory environment is not required in making precise measurements. The small size and weight of the instrument allows easy portability and operation on board surface ships and submarines as well as repair stations and laboratories.

1.2 INSTRUMENT DESCRIPTION The Model PTS-102 is a dual pressure range instrument that may be operated and controlled locally from the front panel, or remotely by a controller on the General Purpose Interface Bus (GPIB, IEEE Std 488). Pneumatic pressure is applied to the appropriate pressure transducer through individual pressure ports for each range. The measured pressure is displayed on the front panel. Equipment and Documentation Supplied is listed in Table 1-1.

Table 1-1 Equipment & Documentation Supplied

ITEM	QTY	DESCRIPTION	MODEL	OVERALL DIMENSIONS	WEIGHT
1	1	Pressure Transfer Standard	PTS-102	14H x 13W x 11D inches Crated: 22H x 21W x 19D inches	24 lbs
2	1	O & M Manual		8.5 x 11 inches approx.	1 lb

1.2.1 Capabilities The Model PTS-102 has the following capabilities listed in Table 1-2.

Table 1-2 Capabilities

1. Pneumatic pressure measurement.
2. Hydraulic pressure measurement. Direct hydraulic pressure or by fluid separator.
3. Pressure to 125% of range without damage to transducers.
4. Independent pressure ports that allow plumbing to independent hi and low pressure systems.
5. External blocking valve manifold optional, for connecting both pressure ranges to single pressure supply system.
6. Local, front panel controls:
   - Display pressure for range selected
   - Range select
   - Zero pressure reset
   - Range test verification
   - Memory test, check sum verification
   - Display error code diagnostics
   - 6 digit display full scale
7. Remote control:
   - Transmit pressure data for range selected
   - Range select
   - Zero pressure reset
   - Range test verification transmitted
   - Memory test, check sum verification transmitted
   - Device clear, return to Power ON initial condition
   - Error code diagnostics transmitted
   - Service request
   - 7 digits of data full scale transmitted
8. Tare offsets using Zero pressure reset
9. Range 1 0-10,000 psig
10. Range 2 0- 1,000 psig

1.2.2 Limitations The Model PTS-102 has the following limitations listed in Table 1-3.

Table 1-3 Limitations

1.	Pressure limited to 125% of range without damage.
2.	Direct hydraulic pressure measurement may cause small shift in calibration due to dielectric of hydraulic oil in contact with transducer.
3.	Tare offsets will introduce error by entering the look up table at other than zero pressure.
4.	Temperature gradients due to high rates of increase or decrease pressure will introduce Temperature Compensation errors.
5.	Long time period for stabilization of reading after high rate of pressure change.
6.	Warm up the instrument for one hour or more to allow stabilization of internal case temperature.
7.	Remote control requires an external controller for the GPIB (IEEE-STD-488-1975).
8.	Rate of pressure increase or decrease should be restricted to less than 1% of range per second on the 1K psig or 10K psig ranges.

1.2.3 Physical Description The Model PTS-102 is a portable instrument for pressure measurement in the field or laboratory. The carrying case is high impact fiberglass, and has a compartment in the lid for the operation manual, power cord, and optional accessories such as the blocking valve manifold. All equipment required for local (manual) operation is contained within the carrying case. Remote control operation requires an external controller (not supplied) for the GPIB (IEEE Std 488-1975) to initiate control and data transfer across the bus. The instrument contains the modules and assemblies listed in Table 1-4.

Table 1-4 Modules and Assemblies

1.	Capacitance Pressure Transducer (Model CPT-301, 302) Range 1 and Range 2
2.	Capacitance Controlled Oscillator (CCO) Range 1(A1) and Range 2(A2)
3.	Period Counter (A3)
4.	CPU, microprocessor (A4)
5.	GPIB, bus interface (A5)
6.	Display MUX & interface (A6)
7.	Power supply +8VDC, +5VDC, -12VDC (A7)
8.	Display Assembly, display driver (A8)
9.	Interconnect assembly & card retainer (A9)
10.	Instrument panel and general hardware

1.2.4 System Support Equipment System support equipment that is an aid in operation or calibration, but not supplied as part of the instrument, is listed in Table 1-5. Items 4 through 12 (or equivalents) are required for major recalibration. Items 1, 2, and 3 are optional equipment.

Table 1-5 Optional System Support Equipment Not Supplied

ITEM	QTY	DESCRIPTION	MODEL PART NO	MFG	OPERATE	CALIBRATE
1	1	Manifold, Blocking Valve (optional)	2375	MGC	X	
2	1	PTS-102 Extender Board	PWA 2377	MGC		X
3	1	IEEE-488 Bus Cable Ass'y	408-30111-301	Amphenol	X	
4	1	Romulator	901-1007	DATA I/O		X
5	2	Ram-Pak w/Interface	901-1006 716-1384-0	DATA I/O		X
6	1	Programmer, Model IX	901-5903	DATA I/O		X
7	1	Program Card Set for Harris, PROM HM1-6611	909-1319-3	DATA I/O		X
8	1	Interface Socket Adapter	1345-1	DATA I/O		X
9	2	Power-Pak	901-1004	DATA I/O		X
10	1	Interface Ram-Pak Programmer	950-0046	DATA I/O		X
11	1	Piston Gage	2400	Ruska		X
12	1	Environmental Chamber (CO2 Refrigerant)	7650C	Delta Design		X

1.3 REFERENCE DATA Reference data for the Model PTS-102 is included in Table 1-6 Functional Specifications, and Table 1-7 Descriptive Nameplate Data.

Table 1-6 Functional Specifications

Measurand:	Pressure
Transducer Type:	Pressure variable capacitor, amorphous quartz
Measurand Range:	Range 1 0 to 10,000 psig Range 2 0 to 1,000 psig
Accuracy:	± 0.01% of full scale, or ±0.05% of indicated value, whichever is greater
Resolution:	Six digit readout with automatic decimal point location between Range 1 and Range 2
Linearity:	Linear within the accurancy specification
Repeatability:	Repeatable within the accuracy specification
Hysteresis:	Hysteresis within the accuracy specification
Long term Stability:	Remains within all performance specification for minimum 6 months (ZERO reset permissible)
Operating Temperature:	15°C to 35°C (60°F to 95°F)
Storage Temperature:	-54°C to 65°C (-65°F to 150°F)
Operating Relative Humidity:	Up to 85% RH
Sample Rate:	Two to three per second
Power:	115VAC ±10V, 60HZ, 1 phase, 30 watts
Dimensions:	14" H x 13" W x 11" D
Output Interface:	GPIB (IEEE-STD-488-1975) with addressable LISTEN/TALK

Table 1-7 Descriptive Nameplate Data

Manufacturer:	Metrology General Corp.
Type:	Pressure Transfer Standard
Model:	PTS-102
Serial Number:	Series from S/N 2000 to S/N 2099

SECTION II
OPERATION

2.1 INTRODUCTION Operation of the Model PTS-102 is easily learned by semi-skilled technicians and requires neither operator dexterity nor operator knowledge of electronics. The operator's responsibilities are outlined in Table 2-1.

Table 2-1 Operator Responsibilities

1.	Control pressure input and rate of change of pressure to maintain safe operating conditions.
2.	Follow operating procedures as described in this section.
3.	Determine if closed pressure system is leak free, and take corrective action as required.
4.	Make judgement of pressure reading stability prior to recording data.
5.	Recognize erroneous data readings and take corrective action as required.
6.	Recognize malfunctions that render this instrument inoperable, and initiate test and corrective action as required.

2.2 SAFETY PRECAUTIONS

1. Power The power supply operates on 115V 60Hz line power. Avoid contact at all times.

WARNING

115V 60Hz power present in instrument. Avoid contact.

2. Hi Pressure Hi pressure pneumatic or hydraulic fluids are present during operation and must always be handled with caution. NEVER allow discharge of hi pressure fluids to come in direct contract with skin, face, and especially the eyes.

WARNING

Hi Pressure Fluids up to 10,000 psi are used during operation. Discharge may cause injury to skin, face, or eyes.

WARNING

DO NOT USE OXYGEN as the pressure media, as the instrument is not cleaned for oxygen use at the factory, and an explosion may result.

2.3 OPERATOR CONTROLS Operator controls consist of four local controls and three remote controls. The instrument is operated in local control except at such time as when the PTS-102 is providing data to another instrument over the General Purpose Interface Bus (GPIB) output system. Refer to Table 2-2 Table of Controls and Indicators, and Figure 2-1 Operator Controls and Indicators.

2.3.1 Local Controls

1. Power ON/OFF The power switch is a two-position push button switch used to apply 115VAC power to the instrument.

2. RANGE Selection The RANGE Selection switch is a momentary push button switch that selects the pressure range to be displayed. Range selection incorporates the selection of transducer frequency and calibration look up table addressing for the pressure range of interest.

3. ZERO The ZERO setting switch is a momentary push button switch that resets the display pressure reading to zero. Actuation of the ZERO switch causes the microprocessor to introduce an offset correction that results in a zero reading in the display for the selected range. The operator must make the judgment as to whether the pressure in the system is actually at atmospheric or zero gage pressure.

4. Range TEST The Range TEST switch provides the operator with an instrument confidence level reading and a Check Sum number. Actuation of the momentary push button switch causes the instrument to display a mid scale pressure reading and then a Check Sum of the microprocessor internal registers. Range TEST and Check Sum operate on either range, and are compared to nominal values on the front panel label.

Table 2-2 Table of Controls and Indicators

CONTROL	LOCAL	REMOTE	INDICATOR
Power ON/OFF	Local control only 115VAC power to instrument	Not Controlled	Display lit
RANGE	Select pressure range 1 or 2	Select pressure range 1 or 2	Adjacent LED lit
ZERO	Reset of zero pressure reading	Reset of zero pressure reading	Zero in display
TEST	Provides mid scale reading	Provides mid scale reading	Change in reading from zero to mid scale number
BUS	Not Controlled	Remote control by GPIB controller ONLY	BUS LED lit

2.3.2 Remote Controls Remote control thru the GPIB allows all controls similar to local control except that power ON/OFF cannot be controlled remotely. The GPIB conforms to the IEEE Std 488-1975, Digital Interface for Programmable Instrumentation.

2.4 INDICATORS Local Indicators provide the operator with status information. Status information may be obtained remotely by the STATUS WORD transmitted over the GPIB. The Local Indicators are:

1. Power ON/OFF Power ON is indicated by the display being lit.

2. Range The selected range is indicated by a lit LED adjacent to the pressure range.

3. Local/Remote Bus Remote control on the GPIB is indicated by a lit LED marked BUS.

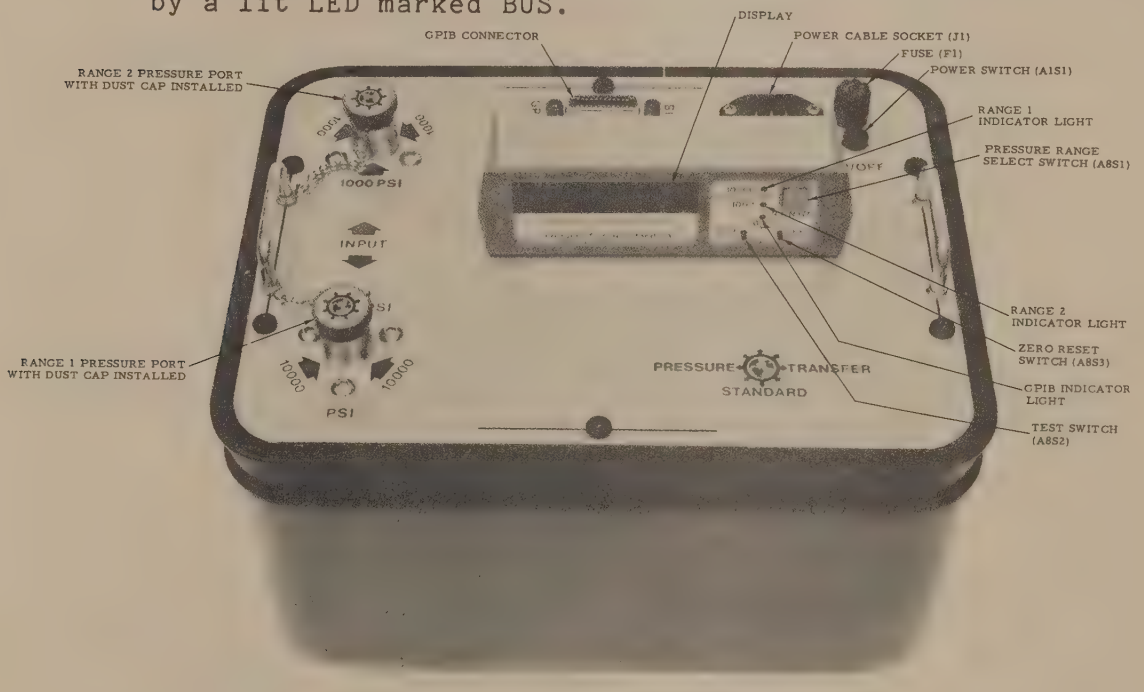


Figure 2-1 Operator Controls and Indicators

2.5 OPERATING MODES Operation of the PTS-102 may be conducted in LOCAL or REMOTE Control.

1. LOCAL Control The standard operating mode is LOCAL wherein the operator has full control of the instrument thru the front panel switches. Power ON initilization

comes up in the LOCAL mode and random pressure range. ZERO reset must be actuated for each selected range.

2. REMOTE Control The REMOTE control mode allows control by a GPIB controller or another instrument on the bus that is dedicated to control the interface with the PTS-102. REMOTE control mode allows control of the PTS-102 at a distance of up to 20 meters of cable length, per IEEE Std 488-1975. Operation in REMOTE control is similar to that in LOCAL except there is no control of Power ON or OFF. ASCII codes for REMOTE control functions are listed in Tables 2-8 and 2-9. ZERO reset must be transmitted for each selected range. During REMOTE operation, data is updated at the same rate as in LOCAL and may be transmitted upon request by the remote controller.

2.6 OPERATION Operation of the PTS-102 consists of preliminary set up as described in Par. 2.6.6 and varying the test pressure from the supply line to prescribed pressure levels. The rate of increase or decrease in test pressure and the settling time allowed at each pressure increment affect the accuracy and drift of the reading. Data is read directly from the front panel display in units of PSI.

2.6.1 Supply Pressure Supply pressure should be regulated to a maximum of 10% above the full scale pressure for the range under test.

WARNING

Do not use OXYGEN as the pressure media, as the instrument is not cleaned for oxygen use at the factory, and an explosion may result.

Nitrogen or hydraulic oil should be used as the pressure media. Nitrogen is preferable when used with a fluid separator to a hydraulic pressure source.

2.6.2 Test Configuration Set Up Test configuration with connections for pressure supply and power are shown in Figure 2-2. Optional use of the GPIB cable for REMOTE operation is also shown.

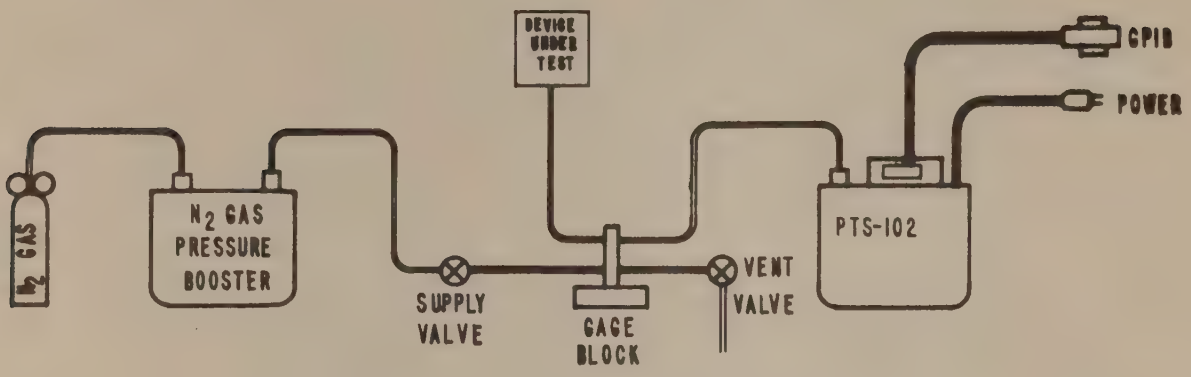


Figure 2-2 Test Configuration

2.6.3 POWER ON Warm Up For maximum system accuracy the instrument should be allowed to warm up with POWER ON and equilibrate in temperature for a period of one hour or more in the laboratory or work space where the pressure measurements are to be performed.

2.6.4 Pressure Exercise Exercise of a pressure range from zero to full scale at least two times will improve the data reading and zero pressure return reading. The exercise should be performed after the warm up period. Exercise of the gauges or instruments under test will frequently improve data readings and zero return.

2.6.5 Pressure Change Rates The rate of change in pressure should be maintained at greater than one minute for full scale pressure change, whether it is increasing or decreasing. Changes in pressure cause adiabatic heating (increasing pressure) and adiabatic cooling (decreasing pressure) within the pressure transducer and pressure media. The resulting temperature gradient thru the transducer element introduce errors that are dependent upon the magnitude of the gradient and the time allowed for dissipation. Thus, pressure changes should be held to within the rates of Table 2-3.

Table 2-3 Pressure Change Rates for Optimum Accuracy

	1K psig Range	10K psig Range
Increasing Pressure	10 psi/sec 600 psi/minute	50 psi/sec 3000 psi/minute
Decreasing Pressure	5 psi/sec 300 psi/minute	30 psi/sec 1800 psi/minute

Much faster pressure change rates are tolerated by the transducer, but larger temperature gradients will result, requiring longer equilibrating time or acceptance of reduced accuracy.

2.6.6 Range Selection When power is turned ON, a pressure range comes up at randum. In order to change the pressure range, depress the RANGE Selection switch on the display panel, hold for a second, and then release. The range lights indicate when the range has switched. Changing back to the previous range is done in a similar manner. If the switch is held too long the range will change back again.

2.6.7 ZERO Reset ZERO reset should be checked after each range change. If at zero pressure the display does not read exactly Zero, depress the ZERO reset switch and hold for a moment until only zeros are displayed. There may be a small, short term fluctuation at zero.

2.6.8 Range TEST Range TEST should be actuated whenever the operator has doubt about the quality of data being obtained. The reading must be made at zero pressure. Depress the TEST switch and hold it until the display changes. The switch may be released now. The number displayed is the mid range test number. If the switch is held in, the second number displayed is a check sum of the memory registers. Both numbers should be checked against the nominal values (for each range) on the label on the front panel. If the numbers are out of range as indicated on the label, refer to the troubleshooting section in Maintenance Section IV.

2.7 DATA ACQUISITION Pressure data displayed may be recorded manually in LOCAL control or with the aid of a programmable data terminal that will interface with the GPIB in the REMOTE control mode.

2.7.1 GPIB Description It is beyond the scope of this manual to describe in detail the GPIB specifications of IEEE-STD 488-1975, but a few basic commands will be presented to aid in REMOTE control operation. The General Purpose Interface Bus (GPIB) is basically a 16-line instrument interface system.

Eight (8) lines are for the transfer of data between instrument on the GPIB. The data may be parametric data, instrument address data, or secondary command word data. Three (3) lines are utilized in the "handshake" mode which synchronizes the transfer of data on the data lines. Five (5) lines are Interface Signal lines used to manage an orderly flow of information across the interface. Further description is included in Table 2-4.

Table 2-4 GPIB Line Functions

GROUP	LINE DESIGNATION	FUNCTION
Data Lines	D I/O 1 thru D I/O 8	Data Transfer
Handshake Lines	DAV	Data Valid
	NRFD	Not Ready For Data
	NDAC	Not Data Accepted
Interface Signal Lines	ATN	Attention
	IFC	Interface Clear
	SRQ	Service Request
	REN	Remote Enable
	EOI	End Or Identify

2.7.2 Capability Definition Table 2-5 lists the GPIB capabilities of the Model PTS-102, as per IEEE-STD 488-1975.

Table 2-5 Capabilities

IDENTIFICATION		DESCRIPTION
SH1	Source Handshake	All capability
AH1	Acceptor Handshake	All capability
T5	Talker	Serial Poll, Talk only, unaddress if my listen address
L4	Listener	Unlisten if my talk address
SR1	Service Request	All capability
RL1	Remote Local	All capability
PP0	Parallel Poll	No capability
DC2	Device Clear	All capability except no selective device clear
DT0	Device Trigger	No capability
C0	Controller	No capability

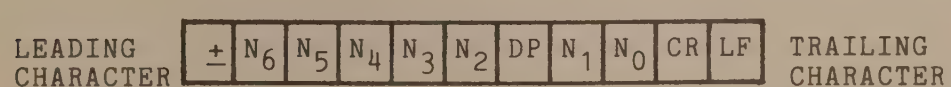
2.7.3 Device Dependent Codes Table 2-6 lists the GPIB Device Dependent Codes recognized by the Model PTS-102.

Table 2-6 Device Dependent Codes

MNEMONIC	FUNCTION
Z	Sets current value of range to represent zero
H	Selects range 1 (10K psig)
L	Selects range 2 (1K psig)
T	Range test: Mid scale value
M	Internal memory test: Check Sum transmitted one cycle only.

2.7.4 Output Data Format The PTS-102 will output data on the GPIB in the format shown in Figure 2-3 when addressed to Talk. Data and characters transmitted on GPIB is in ASCII code shown in Table 2-7.

Figure 2-3 Data Word Format



Serial word, bit parallel data is transmitted beginning with polarity sign, followed by seven digits with decimal point in the appropriate location, and ending with the Carriage Return and Line Feed characters. Leading SPACE digits will be sent as data; thus, each data transmission will consist of eleven (11) words. It is best to determine end of data transmission by detecting Line Feed, rather than counting words. Data will not be retransmitted but will be held off until a new pressure data value is available.

Table 2-7 ASCII Code Transmission

CHARACTER	DESCRIPTION	ASCII CODE
+	Polarity Symbol	2B
-	Polarity Symbol	2D
N_0 thru N_6	Numeric Data	0 thru 9 or SPACE
DP	Decimal Point	2E
CR	Carriage Return	OD
LF	Line Feed	OA

2.7.5 GPIB Instrument Address Each instrument on the GPIB that is required to receive commands and transmit data at specified times must have an address and the ability to recognize its own address. While the maximum number of instruments that may be tied together on the GPIB at one time is 15, there are 31 allowable address code pairs that are switch selectable on the GPIB printed wire assembly (PWA) A5. Instruments are addressed for both Listener and Talker. The addresses are in pairs shown in Table 2-9 and selected by a set of 5 switches on the GPIB PWA. For example, if the switch positions are set 10100, then the Talk Address is T and the Listen Address is 4. No two instruments on the GPIB at the same time may have the same address.

2.7.6 Multiline Bus Commands The PTS-102 shall recognize the multiline commands given in Table 2-8.

Table 2-8 Bus Commands

COMMAND	HEX VALUE	ISO SYMBOL	FUNCTION
GTL	01	SOH	Go to Local
LLO	11	DC1	Local Lock Out
DCL (Note 1)	14	DC4	Device Clear
SPE (Note 2)	18	CAN	Serial Poll Enable
SPD	19	EM	Serial Poll Disable
MLA	20 thru 3E		My Listen Address
MTA	40 thru 5E		My Talk Address
UNL	3F	?	Unlisten
UNT	5F	-	Untalk

NOTE 1: The DCL message sets the following conditions:

a) Clears "zero" registers to zero on both pressure ranges.

b) Both period and gate time counters reset.

c) Pressure range 1 (10K psig) is selected.

d) The program begins at a reinitialize point.

NOTE 2: In response to the SPE function, the status word consists of:

BIT	DATA LINE	MNEMONIC	STATUS
8(MSB)	DIO 8	NDA	New Data Available
7	DIO 7	RFS	Request For Service
6	DIO 6	ERROR	Error Has Occurred
5	DIO 5		Undefined
4	DIO 4		Undefined
3	DIO 3	PERR	Processor Error
2	DIO 2	BERD	Bus Error (Data)
1(LSB)	DIO 1	BERL	Bus Error (Logic)

Table 2-9 Allowable Address Codes

ADDRESS SWITCHES					TALK ADDRESS CHARACTER	LISTEN ADDRESS CHARACTER
A_5	A_4	A_3	A_2	A_1		
0	0	0	0	0	@	SP
0	0	0	0	1	A	!
0	0	0	1	0	B	"
0	0	0	1	1	C	#
0	0	1	0	0	D	$
0	0	1	0	1	E	%
0	0	1	1	0	F	&
0	0	1	1	1	G	'
0	1	0	0	0	H	(
0	1	0	0	1	I	)
0	1	0	1	0	J	*
0	1	0	1	1	K	+
0	1	1	0	0	L	,
0	1	1	0	1	M	-
0	1	1	1	0	N	.
0	1	1	1	1	O	/
1	0	0	0	0	P	0
1	0	0	0	1	Q	1
1	0	0	1	0	R	2
1	0	0	1	1	S	3
1	0	1	0	0	T	4
1	0	1	0	1	U	5
1	0	1	1	0	V	6
1	0	1	1	1	W	7
1	1	0	0	0	X	8
1	1	0	0	1	Y	9
1	1	0	1	0	Z	:
1	1	0	1	1	[	;
1	1	1	0	0	\	<
1	1	1	0	1	]	=
1	1	1	1	0	^	>

2.7.7 Data Acquisition Program A sample data acquisition program, Figure 2-4, written in BASIC is included to allow inexperienced programers to connect to the GPIB. The program is written to run on the Hewlett-Packard Model 9830A calculator. Consult the operating and programing manual for that particular terminal being used to convert the program for your use.

The program combines both test diagnostics and data acquisition. Lines 30-140 remotely program the PTS-102 and then check for service request (SRQ) in lines 160-180. If service is required, the particular request is determined in lines 190-530. If service is not required, the program jumps to 550 and reads data. The program can then be looped back to read more data or take another status reading.

Figure 2-4 Sample GPIB Program to Run On HP-Model 9830 in BASIC Language

```
10 REM : PTS-102 TEST PROGRAM FOR GPIB
20 DIM B[8]
30 REM : DEVICE CLEAR
40 CMD "?U"
50 FORMAT 3B
60 OUTPUT (13,50)256,30,512
70 REM : REMOTE CONTROL
80 CMD "?U"
90 FORMAT B
100 OUTPUT (13,90)768
110 REM : CHECK STATUS WORD
120 CMD "?U"
130 FORMAT B
140 OUTPUT (13,130)256,24,512;
150 OUTPUT (13,130)256,53,84,512;
160 IF (STAT13=1) OR (STAT13=0) THEN 150
170 D=STAT13
180 PRINT "STATUS WORD =";D
190 FOR I=8 TO 1 STEP -1
200 J=I-1
210 A=D-2↑J
220 IF A >= 0 THEN 250
230 B[I]=0
240 GOTO 270
250 B[I]=1
260 D=A
270 NEXT I
280 WRITE (15,490)B[1],B[2],B[3],B[4],B[5],B[6],B[7],B[8]
290 IF B[8]=0 THEN 320
300 PRINT "NEW DATA AVAILABLE"
310 N=1
320 IF B[7]=0 THEN 480
330 PRINT "REQUEST FOR SERVICE"
340 R=1
350 IF B[6]=0 THEN 380
360 PRINT "ERROR IN ";
370 E1=1
380 IF B[3]=0 THEN 410
390 PRINT "PROCESSOR."
400 E2=1
410 IF B[2]=0 THEN 440
420 PRINT "BUS DATA."
430 E3=1
440 IF B[1]=0 THEN 450
450 PRINT "BUS LOGIC."
460 E4=1
470 OUTPUT (13,130)256,25,95,63,25,512;
480 END
490 FORMAT 8F4.0
```

2.8 DATA AND LOGIC ERRORS Internal diagnostic routines provide means of determining instrument errors in data or logic. Table 2-10 Diagnostic Error Codes, and Section IV Maintenance describe the diagnostic error codes and their application to fault isolation.

2.8.1 Error Indication Error codes are displayed along with data on the instrument display panel. The error code appears to left of the data separated by hyphens.

2.8.2 Error Transmission Error codes are transmitted to remote indicators on the GPIB. Codes 1 and 9 are similar in nature, and a distinction is not made between them when transmitted on the GPIB. Error transmission occur upon Serial Pole after Service Request.

2.8.3 Error Correction In general, most data and logic errors will clear on the next reading due to the source of the error being a "glitch". Hardware casualty errors will produce a recurring error code. If this should happen, refer to Section IV Maintenance, and/or return the instrument to an approved repair station.

Table 2-10 Diagnostic Error Codes

CONDITION	DISPLAY CODE	HEX	GPIB ASCII SYMBOL
Bus Logic Error	-0-	61	a
Data Not Located	-1-	64	d
Data Conversion Overflow	-3-	6C	e
Bus Data Error	-4-	70	p
Truncation of B-D Result	-5-	74	t
Add/Subtract Overflow	-7-	7C	:
Loop Time Error	-9-	64	d

SECTION III

THEORY OF OPERATION

3.1 INTRODUCTION The Model PTS-102 operates on a combination of analog and digital circuits in order to excite a pressure transducer and obtain a temperature corrected, linearized pressure data output (Figure 3-1). The pressure measurement is made by detecting pressure with the Metrology General Capacitive Pressure Transducer (CPT-301 and CPT-302)(Pat. Pend.) and its associated Capacitance Controlled Oscillator (proprietary MGC design) which outputs a frequency inversely proportional to pressure. The pressure dependent frequency gates a Period Counter with a digital output to a microprocessor for linearization of data. The microproessor outputs the corrected data to the instrument Display and to the General Purpose Interface Bus (GPIB) upon command of an external ancillary bus controller.

3.2 THEORY OF PRESSURE DETECTION AND MEASUREMENT Pressure is detected by a highly stable, repeatable pressure sensitive capacitor. Stability and repeatability are characteristics of the material used in making the pressure sensitive capacitor. It has been determined that amorphous quartz is very stable and repeatable due to its high Modulus of Elasticity (10.2×10^6). From fundamental physics, the

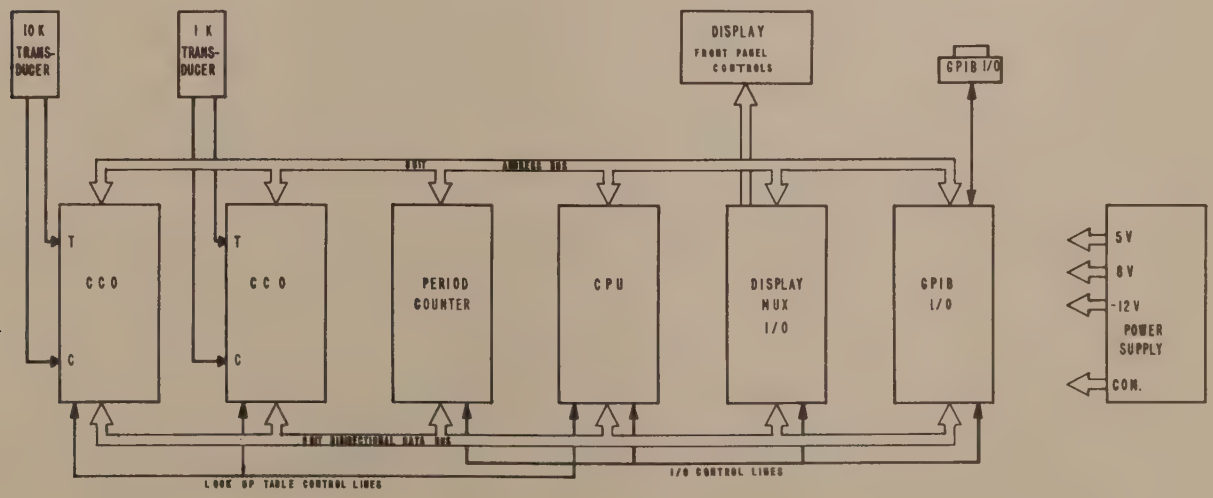


Figure 3-1 System Block Diagram

Modulus of Elasticity, or Young's Modulus is defined as:

$$E = \frac{\text{Stress}}{\text{Strain}} \qquad (3\text{-}1)$$

Stress is represented by the applied pressure (P) and the resulting strain is the deflection (d) or bending of the pressure sensitive capacitor. Amorphous quartz has a temperature coefficient (α_E) of Young's Modulus which is essentially linear over the instrument operating temperature range. Equation 3-1 can be rearranged to solve for the strain or deflection and include the influence of temperature, which results in equation 3-2.

$$d = \frac{k_1 P}{E_o \left[1 + \alpha_E (T - T_o)\right]} \qquad (3\text{-}2)$$

Where:
- d = deflection or strain
- T = temperature
- T_0 = Reference Temperature (25°C)
- E_0 = Young's Modulus at T_0
- α_E = Temperature Coefficient of E_0
- P = Pressure or stress
- k_1 = proportionality constant

Thus the deflection of the pressure sensitive capacitor is directly proportional to the applied pressure and inversely proportional to temperature.

The capacitance with respect to the pressure induced deflection is:

$$C = \frac{k_2 A}{G - d} \qquad (3\text{-}3)$$

Where:
- C = Transducer Capacitance
- k_2 = proportionality constant
- A = Area of capacitance plates
- G = gap between capacitance plates (zero psig)
- d = deflection of plates due to pressure

Increasing pressure causes increasing capacitance as shown in equation 3-3. For a typical RC oscillator to convert the change in capacitance to change in frequency, the relationship of equation 3-4 is valid.

$$f = k_3 \frac{1}{RC} \qquad (3\text{-}4)$$

Where: f = frequency
k_3 = proportionality constant
R = Precision resistor in oscillator
C = transducer capacitance

Combining equations 3-2, 3-3, and 3-4 and solving for frequency f:

$$f = \frac{k_3 G}{k_2 AR} - \frac{k_1 k_3 P}{k_2 AR\ E_0[1+\alpha_E(T-T_0)]} \qquad (3\text{-}5)$$

The first term of equation 3-5 represents the zero pressure frequency contribution, while the second term is the pressure related frequency term. The first term is always larger than the second term, and thus the frequency decreases as pressure increases.

3.3 PRESSURE TRANSDUCER The Capacitance Pressure Transducer Model CPT-301 and CPT-302 is a patented design of Metrology General Corporation. The basic description of the transducer is a pressure variable capacitor that is highly repeatable for a given pressure and temperature. The repeatability can be attributed to the amorphous quartz structure forming the pressure variable capacitor. Amorphous quartz as compared to crystalline (piezioelectric) quartz is far less sensitive to manufacturing technique and temperature related errors. Amorphous quartz is a fused, glass-like, non-crystalline material that has superior elastic properties and extremely low thermal coefficient of linear expansion.

3.3.1 Transducer Structure The transducer structure forms a pressure variable capacitor. The capacitor consists of a reference element and an active element. The two elements or plates as shown

in Figure 3-2 of the capacitor are in the form of two concentric cylinders with a very small air gap between the capacitive plates. The reference element and the air gap are held at atmospheric pressure, while the test pressure is applied to the exterior surface of the active element. The pressure displaces the active element toward the reference element, thus narrowing the gap and increasing the capacitance. The value of capacitance for any given pressure and temperature is highly repeatable due to the quartz material and the construction technique.

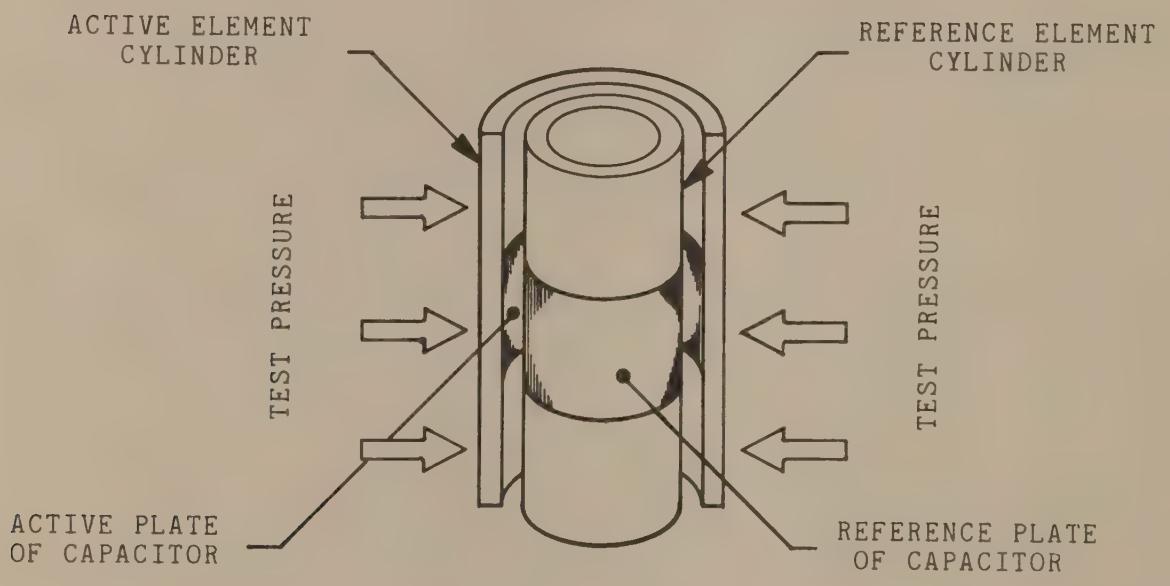


Figure 3-2 Pressure Transducer Element Cut Away View of Quartz Element With Pressure Housing and End Dome Removed

3.3.2 Temperature Effect The temperature of the pressure transducer is dependent upon the ambient room temperature and the adiabatic heating or cooling (increasing or decreasing pressure respectively) of the pressure media. The effect of temperature change due to the coefficient of linear thermal expansion is small (5.5×10^{-7} cm/cm/c^{o}), but the temperature coefficient of Young's Modulus (Modulus of Elasticity) is large (+180ppm/c^{o}) and must be compensated. The effect of the temperature coefficient of Young's Modulus is to cause the

amorphous quartz to become stiffer as the temperature increases. As the transducer element becomes stiffer, less deflection or less change in capacitance occurs for a given applied pressure.

3.3.3 Temperature Compensation The effects of ambient temperature and adiabatic heating and cooling cause an error in the indicated value of pressure. This error is corrected by the Temperature Compensation circuit located on the Capacitance Controlled Oscillator (CCO) Printed Wire Assembly (PWA). The temperature of the amorphous quartz and the pressure media is detected with a thermistor bonded to the quartz within the pressure housing. The thermistor output is utilized in the temperature compensating circuit to reduce the temperature related errors.

3.4 CAPACITANCE CONTROLLED OSCILLATOR The Capacitance Controlled Oscillator Assembly (P/N 2340) shown in Figure 3-3 Block Diagram is a proprietary design of Metrology General Corporation. The CCO is a charge transfer oscillator in which the transducer cpacitor is charged to a reference voltage and then discharged to the input of a precision integrator. The operation is based on the two fundamental electrical relationships:

$$Q = CE \text{ (charge relationship)} \quad (3\text{-}6)$$

$$Q = \int Idt \text{ (discharge relationship)} \quad (3\text{-}7)$$

Where: Q = electric charge (coulombs)
C = capacitance of the transducer
E = applied potential of reference voltage
I = discharge current
dt = derivative of time

3.4.1 CCO Functional Description The block diagram of the oscillator is shown in Figure 3-3. When switches S1 and S4 are turned ON and S2 and S3 are OFF, the transducer capacitor will charge to the reference voltage. Switches S3 and S4 are then toggled to connect the grounded side of the capacitor to the input of the integrating amplifier, which is also at virtual ground potential.

Then, switches S1 and S2 are toggled to connect the reference voltage side of the capacitor to ground, thus discharging the capacitor to the input of the integrating amplifier. When the capacitor is fully discharged, switches S3 and S4 are toggled to their original position connecting one side of the capacitor to ground. The last step of the sequence is for switches S1 and S2 to return to their original position and begin charging the transducer capacitor again. During the period of time when the capacitor is charging (equation 3-6), the precision resistor will transfer charge from the reference voltage to the input of the integrator accurately expressed by equation 3-7 and Ohms Law. The integrating amplifier, voltage controller oscillator, and switching logic adjust the switching frequency to such a rate that the charge through the precision resistor will equal the charge from the capacitor into the integrator. A closed loop is formed by the integrator, VCO, switching logic and the precision resistor and capacitor. The excellent stability of the oscillator is a result of this closed loop that is only dependent upon the stability of the precision resistors and the transducer capacitor.

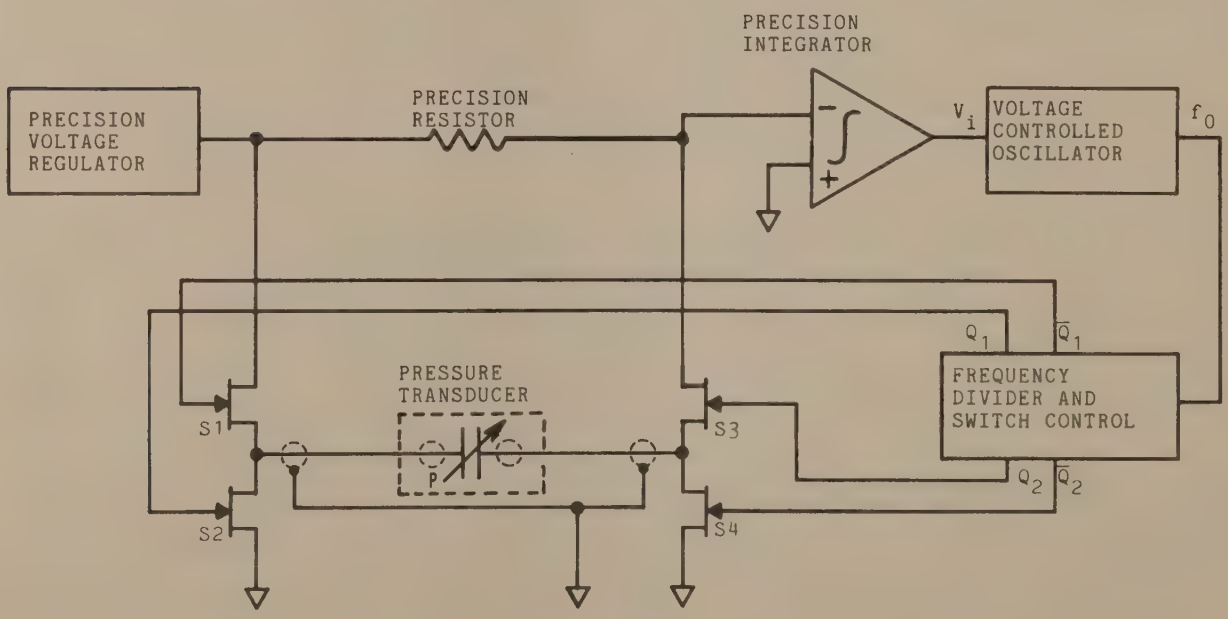


Figure 3-3 Capacitance Controlled Oscillator Block Diagram

3.5 PERIOD COUNTER ASSEMBLY The Period Counter Assembly (P/N 2343) accepts the sensor and reference frequency from two sensor assemblies, performs a period count, and stores and outputs the data under control of the CPU assembly. The CPU can also direct the range selection and the operation of a test mode via the address bus. A block diagram of the Period Counter is shown in Figure 3-4.

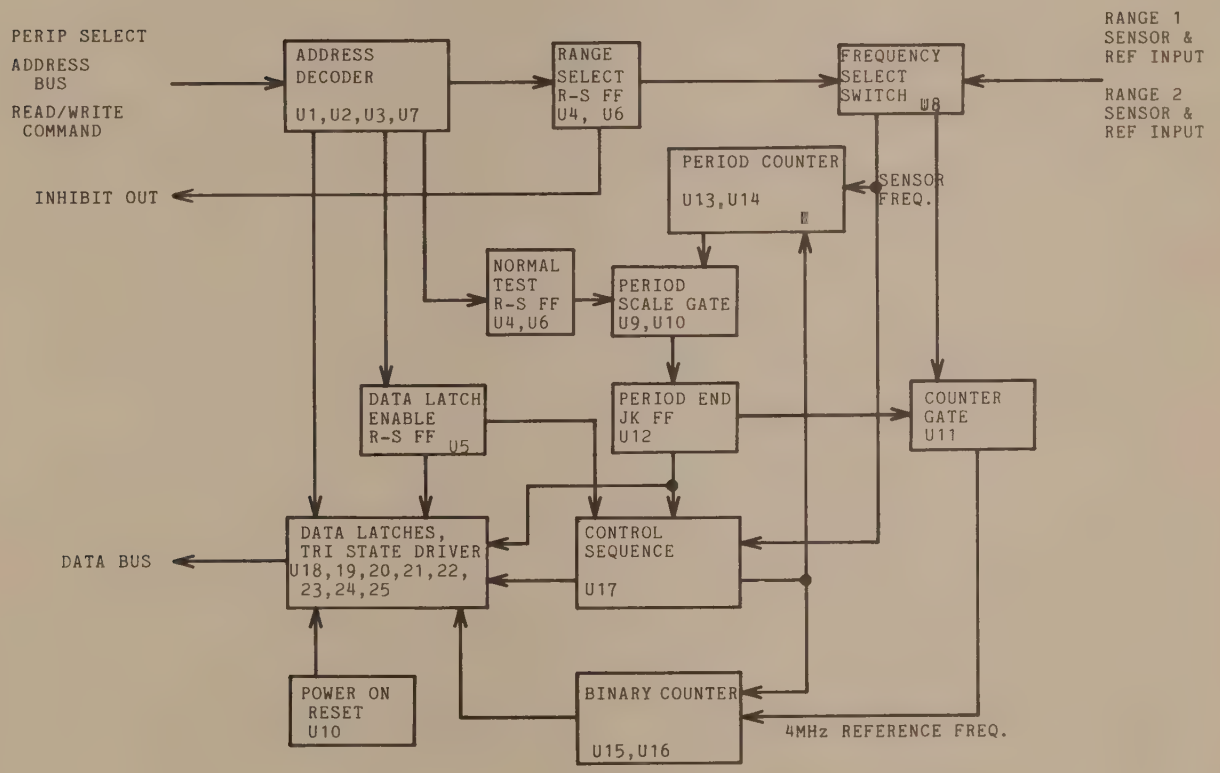


Figure 3-4 Period Counter Block Diagram

3.5.1 Period Counter Function Ripple counters are used to count the selected sensor frequency and the selected reference frequency. The reference frequencies are 4MHz which allows a period resolution of 250 nanoseconds. The period counter is allowed to count for 131074 ($2^{17}+ 2^{1}$) cycles of the sensor frequency in the normal operating mode and 196610 cycles ($2^{17}+ 2^{16}+ 2^{1}$) in the test operating mode.

With the reference frequency gate open for this time, the resulting count is:

$$\text{Counts} = 4{,}000{,}000 \text{ counts/sec} * \frac{131074 \text{ cycles}}{f_{sensor} \text{ cycle/sec}} \qquad (3\text{-}6)$$

Under normal operation the counts vary from approximately 1,000,000 at zero pressure to 2,000,000 at full scale pressure.

3.5.2 Counter Control Timing Figure 3-5 illustrates the Period Counter Control timing. At the end of the count of the sensor cycles, a signal level is sent to the status register of the counter and to the control sequence chip. If the data latch has been enabled, the new data will be stored in the data latch, the counters will reset and the cycle will begin again. If the data latch is not enabled, the counters will stop and wait until data storage is allowed.

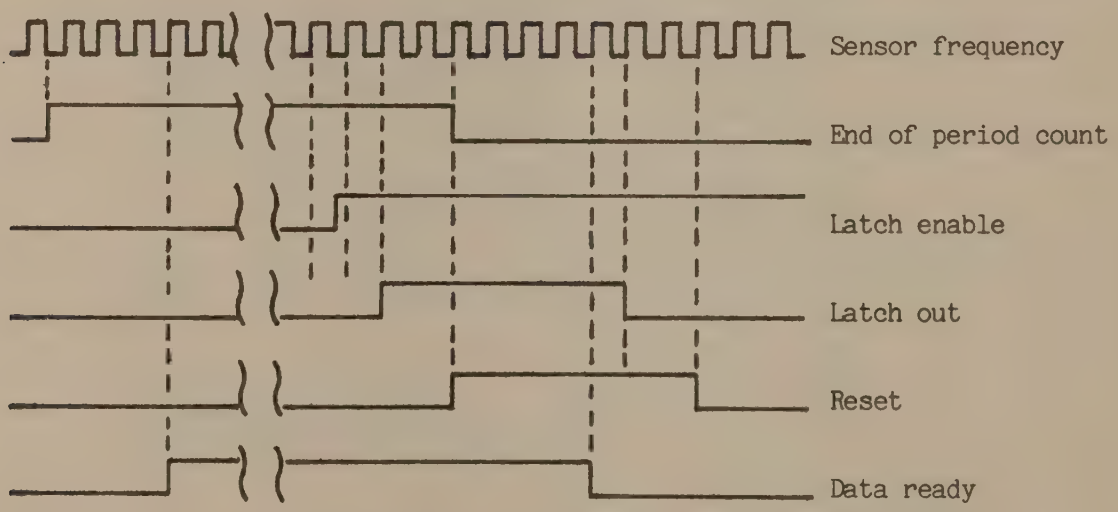
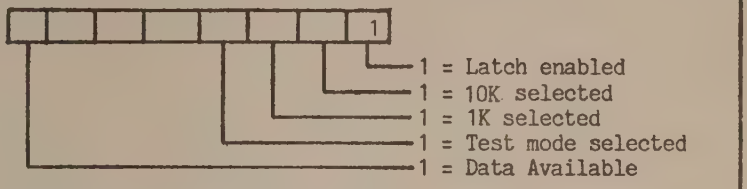
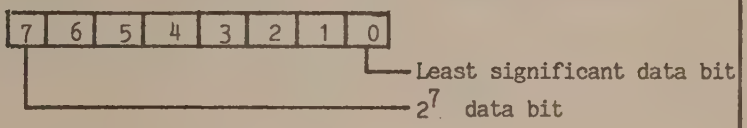
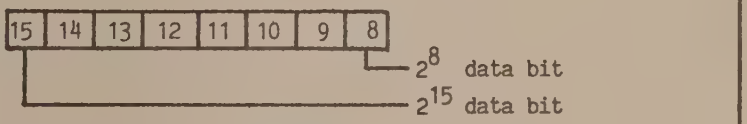
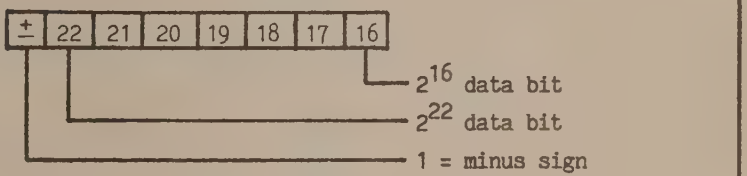


Figure 3-5 Counter Control Sequence Timing

3.5.3 Peripherial Addressing The counter assembly is accessed by the computer by selecting the peripherial line, ($\overline{\text{PERIP}}$ is activated by using memory address 'FDXX'H), the device code (selected by jumper on the counter assembly, normally set to 2 for the counter in the PTS-102), and the function desired. Table 3-1 gives the available functions.

Table 3-1 Available Functions of Period Counter

* R = read		W = write	A = addressable write
ADDRESS	MNEUMONIC	OPR*	CONTENT
FD20	CSTAT	R	
FD21		R	
FD22		R	
FD23		R	
FD24	LE	A	A write to this address enables data latch
FD25	NLE	A	A write to this address disables data latch
FD26	RTEN	A	A write to this address selects range 1, deselects range 2 (i.e. inhibit range 2)
FD27	RONE	A	A write to this address selects range 2, deselects range 1 (i.e. inhibit range 1)
FD28	RTST	A	A write to this address sets # sensor periods to 196 610 (test mode)
FD29	RCLR	A	A write to this address clears test mode and resets latches to zero value
FD2A - DD2F			Not Used

3.6 CPU ASSEMBLY The CPU Assembly (P/N 2355) is the computing assembly of the PTS-102. The assembly is responsible for controlling the collection of data from the sensor oscillators, controlling the processing of the data and the display of the result, controlling the IEEE-488 bus, and controlling the responses to switch commands.

Additionally, the assembly is responsible for retrieving the calibration data from the sensor look-up table and utilizing this information in computing the pressure value.

3.6.1 CPU Function Description Figure 3-6 shows the operational blocks in the CPU Assembly. The assembly contains the micro processor chip, Read Only Memory (ROM), Random Access Memory (RAM), and timing buffer and control circuits necessary for accessing and controlling the other circuit assemblies in the system. The ROM is 2088 bytes long and contains the operating program. Details on operation of the program are given elsewhere is this manual. The RAM is 256 bytes long and the usage of the RAM is contained elsewhere.

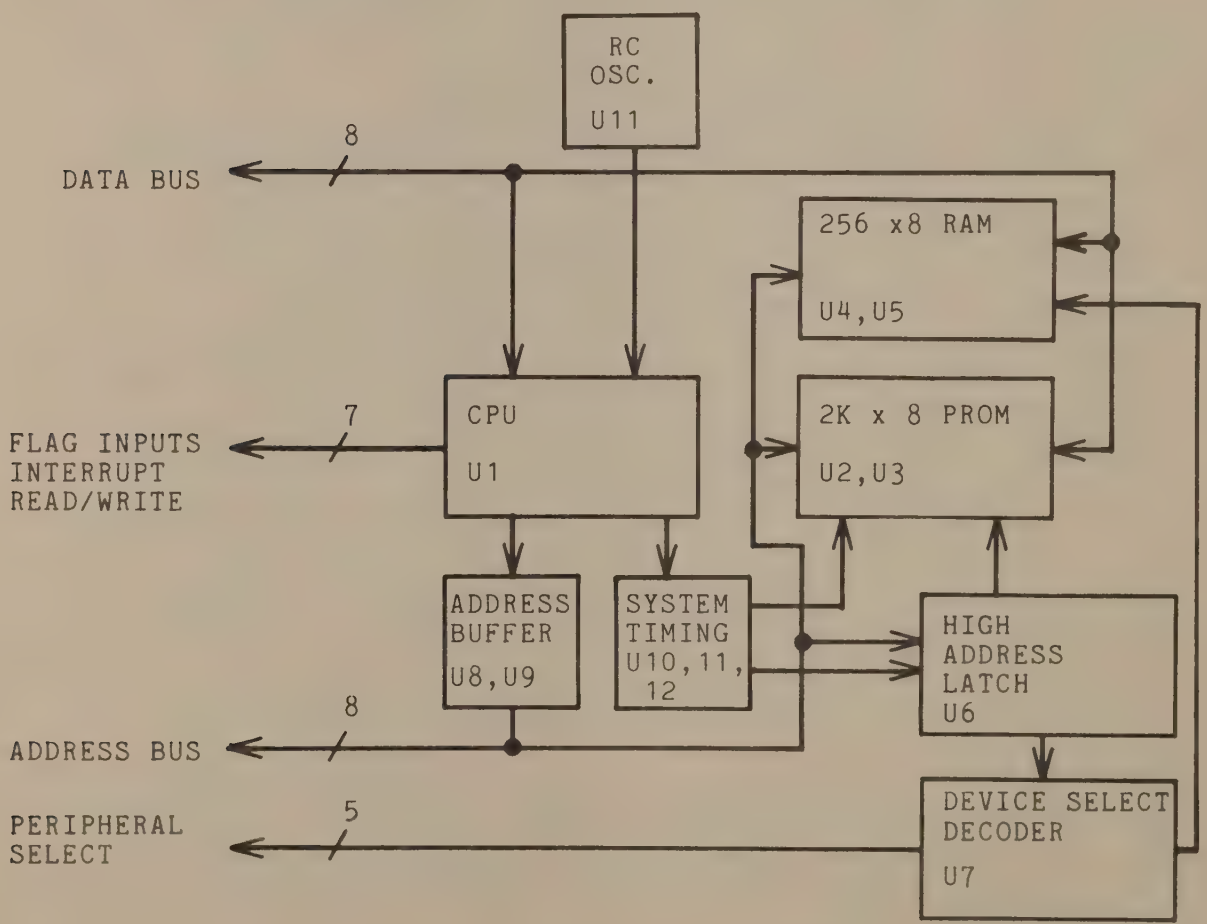


Figure 3-6 CPU Block Diagram

3.6.2 Peripherials Addressing Peripherial circuit assemblies are selected via a device select decoder which uses the high order (upper 8 bits) byte of the memory address as its input. Memory mapped I/O allows reading and writing data to the peripherial circuit assemblies as though they were a part of the memory.

3.7 GPIB ASSEMBLY The GPIB Assembly (P/N 2352) provides the interface from an IEEE-Std 488-1975 bus to the PTS-102. In this role it takes control over the general management portion of the bus and the data handshake portion. The block diagram is shown in Figure 3-7. The GPIB Assembly interrupts the CPU to interpret commands on the data bus and take action as appropriate.

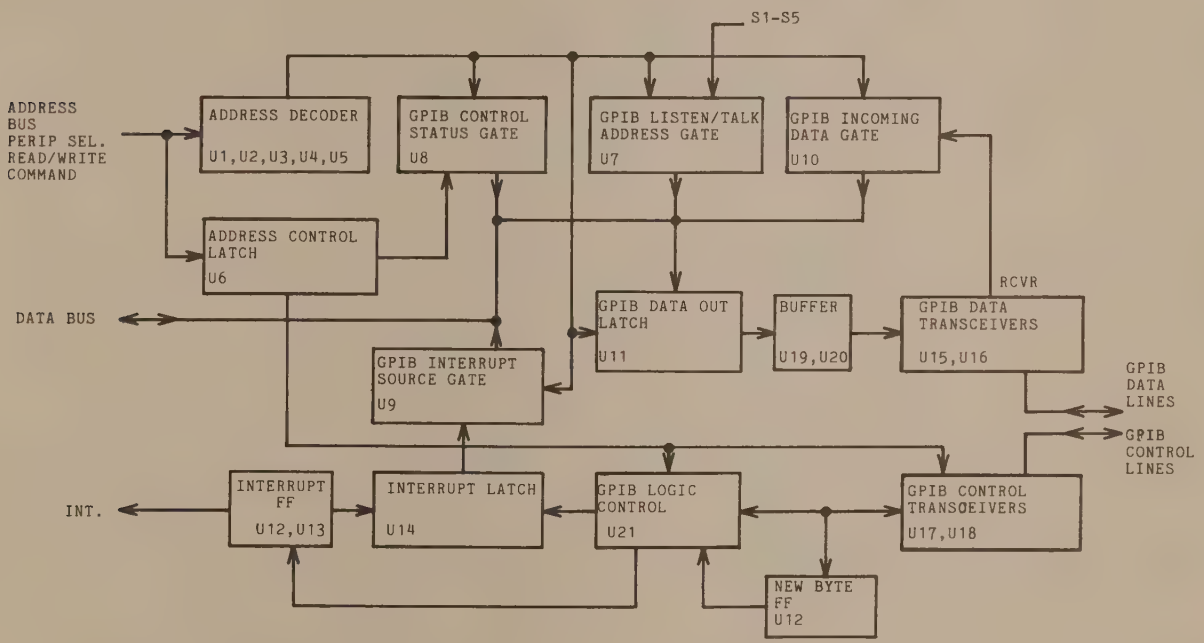


Figure 3-7 GPIB I/O Block Diagram

3.7.1 GPIB Functional Description Data to and from the bus is buffered by bus transceivers designed to provide the required impedance levels and drive levels to meet IEEE-488 requirements. The reactions to commands on the assembly is controlled by the logic control circuitry made up primarily by a field programmable logic array (FPLA). This device is a collection of AND or OR gates,

inverters and EXCLUSIVE OR gates. It accepts commands from the GPIB and internal status levels, and generates logical outputs to the GPIB. It requests processor intervention only when data needs to be transferred on the bus. When this is done, the source of the interrupt is saved so the processor may determine the action it must take; i.e., accept one byte of the data, send one byte of data, etc.

3.7.2 LISTEN/TALK Addressing Gates are provided to access the listen/talk address switch setting, incoming data, bus status and interrupt source. An output port is also available for sending data on the bus.

3.7.3 GPIB Peripherial Addressing Access to the bus is attained by selecting peripherial ($\overline{\text{PERIP}}$ is selected by addressing 'FDXX'H), the device selection code (the GPIB Assembly normally uses two codes, 4 and 5 in the PTS-102), and the desired function. The functions that are available are given in Table 3-2 following.

3.8 DISPLAY DECODER/MUX AND DISPLAY ASSEMBLIES The Display Decoder/Mux Assembly (P/N 2349) and the Display Assembly (P/N 2346-1) shown in Figure 3-8, provides the operator interface via a display for the data output and switches for operator control of the PTS-102. The display decoder accepts data from the CPU assembly, stores the data, and displays the data with appropriate sign and decimal point on the front panel display. The display decoder also provides the electrical interface between the front panel switches and the CPU assembly.

3.8.1 Data Mux Data is multiplexed on the 8 digit gas discharge display with the digit and segments being driven by medium scale integrated circuit drivers designed for exactly that purpose. The power for the display is derived from a DC-DC converter using the +5VDC logic supply, which it converts to a $\pm$100VDC supply for the display.

3.8.2 Data Decoder The display decoder assembly continually scans the 8 digit by 4 bit register and applies the BCD digits to a BCD to

seven segment decoder. Additionally, it samples the decimal point register to locate the appropriate time to apply the decimal point. The digit driver and the segment driver are blanked between digits

Table 3-2 Available Functions to GPIB

* R = read		W = write	A = addressable write
ADDRESS	MNEUMONIC	OPR*	CONTENT
FD40	IB DATA	R/W	LSB = 2^0 of Data MSB = 2^7 of Data
FD41	IB INT	R	Acceptor data ready Always "1" Acceptor not ready Remote enabled
FD42	IBSTAT	R	Listener Addressed Talker Addressed Serial Poll Memory State Attention on
FD43	IBMLA	R	LSB Listen Address 2^4 Address bit Always "1" Always "0"
FD44	IBMTA	R	LSB Talk Address 2^4 Talk Address bit Always "0" Always "1" Always "0" Note: The least significant 5 bits of the listener and talker address are always the same.
FD45 - FD4F			Not Used
FD50	IBNBA	A	Clear excitation for new byte
FD51	IBCLRQ	A	Clear request for service
FD52	IBCLEI	A	Clear End or Identify line
FD53	IBCLSP	A	Clear Serial Poll State
FD54		Not Used	
FD55	IBCLMT	A	Clear talker addressed state
FD56	IBCLML	A	Clear listener addressed state
FD57	IBCLRY	A	Clear ready for data excitation
FD58	IBCLNB	A	Set excitation for new byte
FD59	IBSRQ	A	Set request for service
FD5A	IBEOI	A	Set End or Identify
FD5B	IBSPMS	A	Set Serial Poll State on
FD5C		Not Used	
FD5D	IBMTAS	A	Set talker addressed state
FD5E	IBMLAS	A	Set listener addressed state
FD5F	IBRFD	A	Set ready for data excitation

according to the manufacturer's recommendations. The blanking occurs for 1/8 cycle before and 1/8 cycle after selection of the next digit, resulting in a 3/4 operating duty cycle.

3.8.3 Indicator Three LEDs for indicating range and for indicating when the unit is connected to the IEEE-488 bus, as well as three inventory switches for selecting zero, range change, and test functions are mounted on the display assembly.

3.8.4 Peripherial Addressing The data is written into the display via the data bus by selecting the peripherial ($\overline{\text{PERIP}}$ is selected by addressing 'FDXX'H), the device code (normally set to 7 for the display decoder in the PTS-102), and the desired functions. The functions available are shown in Table 3-3.

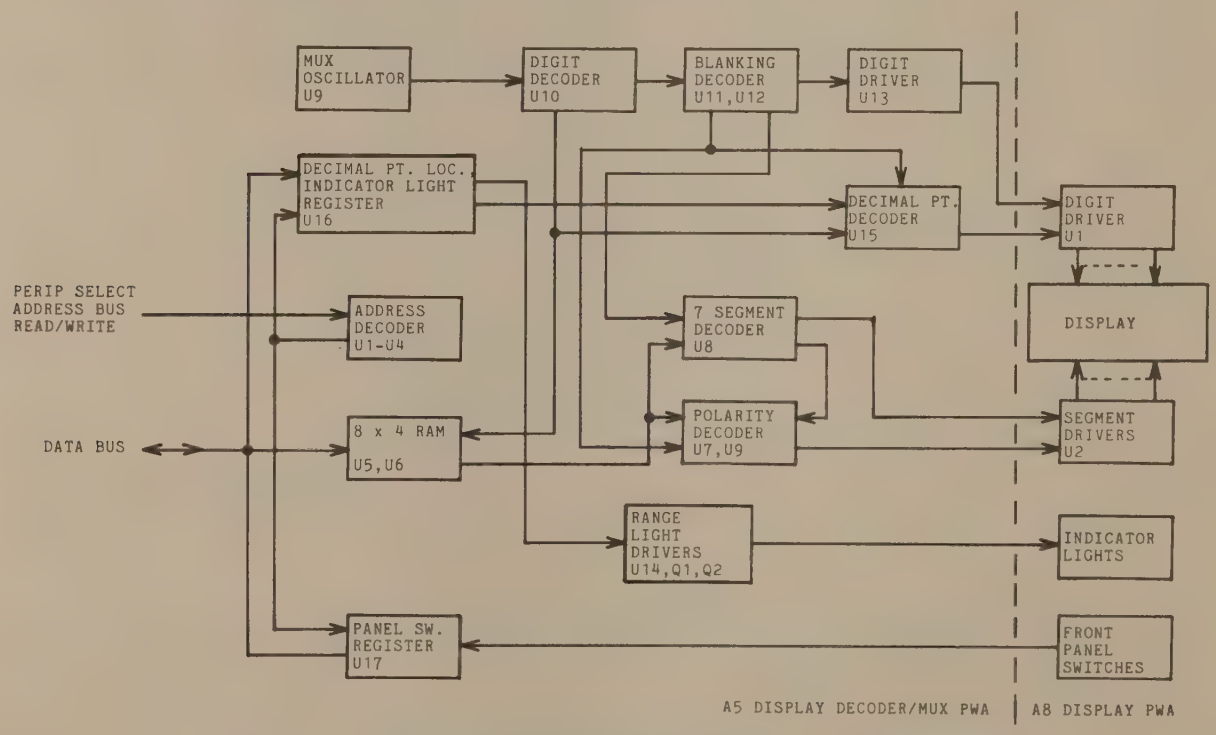


Figure 3-8 Display Decoder/Multiplexer I/O Block Diagram

3.9 POWER SUPPLY Power requirements for the Model PTS-102 consists of three voltages of which two are well regulated and the third is not. The +8VDC and -12VDC utilized by the Capacitance Controlled

Oscillator are well regulated to improve stability and repeatability of pressure readings. The digital portion of the PTS-102 operates from a +5VDC supply rated at 1.5A. The gas discharge display operates from the +5VDC supply, and is converted to ±100VDC in the Display Assembly.

Table 3-3 Available Functions of Display Decode Mux

*R = read W = write A = addressable write

ADDRESS	MNEUMONIC	OPR*	CONTENT
FD70		R/W	Digit 1, LSD, LSB Digit 1, LSD, 2^1 bit Digit 1, LSD, 2^2 bit Digit 1, LSD, 2^3 bit
FD71		R/W	Same as FD70 except 2nd digit
FD72		R/W	Same as FD70 except 3rd digit
FD73		R/W	Same as FD70 except 4th digit
FD74		R/W	Same as FD70 except 5th digit
FD75		R/W	Same as FD70 except 6th digit
FD76		R/W	Same as FD70 except 7th digit
FD77	MSDIG	R/W	Same as FD70 except 8th digit
FD78	SWIN	R	0 = test switch on 0 = 10K indicator on 0 = range charge switch on 0 = zero switch on
FD79 - FD7B		Not Used	
FD7C		W	Decimal Point position 2^0 Decimal Point position 2^1 Decimal Point position 2^2 1 = 1K Light set on
FD7D to FD7F		Not Used	

THIS PAGE LEFT BLANK

SECTION IV
MAINTENANCE

4.1 INTRODUCTION The scope of this section on Maintenance of the PTS-102 includes the three levels of maintenance. Responsibilities and scheduled tests at Level 1 (Operator), Level 2 (Intermediate), and Level 3 (Repair Depot) maintenance are described; as well as, scheduled maintenance, troubleshooting, and corrective maintenance.

4.2 QUALIFIERS Maintenance at Levels 2 and 3 should be performed by competent electronic technicians familiar with reading schematics, following troubleshooting procedures, and working with integrated circuit electronics.

4.3 CAUTIONS Due to the nature of the PTS-102 electronics and the instrument's mission, the following Cautions and Warnings MUST be observed.

WARNING

This instrument operates from external High Pressure of 10,000 PSI. Exercise the proper caution to prevent injury.

WARNING

This instrument operates from 115 VAC power, and may cause an electrical shock that could be hazardous to your health. Turn power off before working on instrument.

WARNING

EXPLOSION may result from using oxygen as pressure media. DO NOT use oxygen as a pressure media. Instrument is NOT LOX clean at factory.

CAUTION

CMOS Integrated Circuits utilized in this instrument are subject to damage by electrostatic discharge. DO NOT touch IC leads. Always use wrist strap ground when handling CMOS ICs.

4.4 TEST EQUIPMENT AND TOOLS Table 4-1 is a list of test equipment and tools required for maintenance but not furnished with the PTS-102.

Table 4-1 Test Equipment and Tools

ITEM	DESCRIPTION	PART/MODEL NO	MFG	WHERE USED
1	Oscilloscope dual beam	Model 5443	Tektronix	Wave forms and timing
2	Logic Analyzer 16 line	Model 1600A	Hewlett-Packard	Microprocessor and logic timing
3	Digital Multi Meter 4 1/2 digit	Model 3465A	Hewlett-Packard	Voltage and resistance measurements
4	Ram Pak	901-1006	DATA I/O	PROM Emulation
5	Programmer IX	Model IX	DATA I/O	Look up Table PROM Programmer
6	Precision Dead Weight Piston Gage	Model 2400 HL	Ruska	Pressure generator for re-calibration
7	Environmental Chamber	7650C	Delta Scientific	Temperature compensation during re-calibration
8	GPIB Controller	Model 9830A	Hewlett-Packard	Operation and test of GPIB
9	Frequency Counter	Model 5328	Hewlett-Packard	Measure frequency of Cap. Controlled Oscillator output
10	Personality Card Set: Harris HM1-6611	909-1319-3	DATA I/O	Interface to Harris HM1-6611
11	PROM Socket Adapter	1345-1	DATA I/O	Interface to Harris HM1-6611
12	Power Pak	901-1004	DATA I/O	Power to Romulator and Ram Pak
13	Romulator	901-1007	DATA I/O	Manual entry of data to Ram Pak
14	Ram Pak Interface	716-1384-0	DATA I/O	Connect Ram Pak to circuit
15	Extender Board	PWA 2377	MGC	PWA Test

4.5 SCHEDULED MAINTENANCE Scheduled maintenance is described for each level of maintenance. The schedules are recommended as a preventive maintenance as well as a determination of proper operation, and are summarized in Table 4-2.

Table 4-2 Scheduled Maintenance

D: Daily Q: Quarterly S: Semi-Annually			
INTERVAL	MAINTENANCE LEVEL	MAINTENANCE ACTION	REFERENCE PARAGRAPH
D	1	Log initial Zero press reading (both ranges)	4.5.1.2
D	1	Check range TEST number	4.5.1.3
D	1	Check memory TEST number	4.5.1.3
D	1	Check cleanliness of pressure ports and caps in place	4.5.1.4
	2	None Recommended	4.5.2
Q	3	Calibration comparison	4.5.3.1
S	3	Calibration comparison	4.5.3.1
S	3	Test transducer cleanliness	4.5.3.2

4.5.1 Level 1 Operator Scheduled Maintenance There are several steps the operator should perform prior to the start of data collection each day.

1. The operator should first allow the proper warm up of one hour before taking data.
2. The initial zero pressure reading should be logged on a daily basis before the ZERO reset switch is pressed. This number could indicate the start of calibration problems if the day to day number changes by a large amount or a different amount. Note if the number logged is a Power ON zero offset or a zero drift from the previous day, with the instrument running continuously.
3. The operator should then actuate the ZERO reset switch before obtaining the Range TEST and Memory TEST numbers. The Range TEST number should fall within the range specified on the TEST label. The Memory TEST number must be exactly the same number as on the TEST label.

4. Pressure ports must remain clean and free of oils. Dust caps must be installed whenever the pressure port is not in use.

Discrepancies are cause to proceed to Troubleshooting Guide, Par. 4.6, or submit the instrument to a higher maintenance level. A summary of Level 1 scheduled maintenance is included in Table 4-2.

4.5.2 Level 2 Intermediate Scheduled Maintenance No intermediate level scheduled maintenance is recommended.

4.5.3 Level 3 Repair Depot Scheduled Maintenance Repair Depot level scheduled maintenance consists of calibration testing and cleaning of transducers to prevent contamination of test gauges and instrument.

1. Compare indicated values of PTS-102 with appropriate precision dead weight piston gauge. Determine if readings are in specification.
2. Test transducer for hydrocarbon contamination. Clean a short length of pressure tubing with Freon and test for hydrocarbon contamination. Connect the PTS-102 directly to a dry N_2 cylinder and regulator with the clean tubing. Pressurize and vent 5 to 10 times. Test the tubing once again for hydrocarbon contamination. If contamination is excessive, refer to cleaning instructions of Par. 4.8. Repeat procedure for second pressure range.

Discrepencies are cause to proceed to troubleshooting, repair, cleaning and/or calibration adjustments.

4.6 TROUBLESHOOTING AND FAULT ISOLATION Troubleshooting and fault isolation should be approached by first identifying all the symptoms of the malfunction, then isolating the possible casualty to a particular Printed Wire Assembly (PWA).

4.6.1 Symptoms Identification Symptoms of a malfunction may be identified in three different approaches:

1. Display, range lights, and control switch failures are the most obvious symptoms of malfunctions when the instrument is first turned ON.
2. Error codes displayed during operation are a positive indication of a fault, but the error may be due to a short duration transient and flash only once or twice. The PTS-102 performs seven self test diagnostic routines that result in an error code displayed along with data if an error is detected (see Table 4-4).
3. Erroneous data displayed is a difficult symptom to detect and generally requires comparison to another pressure measuring instrument unless the error is of a very large magnitude.

34.6.2 Fault Isolation Isolation of the fault to a particular PWA may be aided by use of the Troubleshooting Guide Table 4-3. For any given set of symptoms, the fault should first be isolated to one or two boards and then verified by PWA substitution with a known good board. The PTS-102 performs seven self test diagnostic routines (Tables 4-3 and 4-4) that result in an error code displayed if an error is detected.

4.6.3 Component Troubleshooting CMOS integrated circuits in the digital portion (A3-A6) of the PTS-102 have 100 OHM resistors installed in series with their +5VDC power lead. Thus, a malfunction of an IC can often be detected by just searching for that component which has a larger voltage drop across its series resistor. CMOS integrated circuits generally draw microamps of current when operating properly. When higher current is drawn, due to a short or linear operation, the voltage drop across the resistor may amount to several hundred millivolts to volts. Malfunctions that appear to be address related would suggest checking components associated with address decoding. Likewise, malfunctions related to data or logic timing suggest checking components associated with their respective functions (one to many lines).

Table 4-3 Troubleshooting Guide

STEP	SYMPTOM	POSSIBLE CASUALTY	CORRECTIVE ACTION	SUSPECT ASSEMBLY
1	Display not lit Range light not lit	Loss of power	Check power cord properly connected	W1
			Check display cable for proper connection	W2
			Check fuse	F1
2	Display not lit One range light is lit	Loss of power to display	Check display cable for proper connection	W2
			Check continuity of power lead in display cable	W2
			Check for +100 VDC on A8, U1, Pin 12	A8
			Check for -100 VDC on A8, U2, Pin 13	A8
		Program not running	If error code -9-, make range change	A4
			If no error code, power OFF (wait 5 seconds)/ON for power reset	
			Check CPU clock on A4	A4
3	Display lit Range light not lit	IC failure	Check A6, A14	A6
		LED failure	Check second range for lit LED	A6
4	BUS light remains lit	GPIB maintains control	Issue DCL device clear from bus controller	
		Program hung up in GPIB Sub routine	Turn power OFF (wait 5 seconds)/On for power On reset	A5
5	No response to control switches or to any one control switch	Switch failure	Check continuity of switch at back of A8	A8
		Cable malfunction	Check continuity of cable W2	W2
		Data latch failure	Check U17 on A6	A6
		Program not responding	If memory TEST switch still operating, check that program is complete (same "memory" number)	A4
		GPIB in Local Lockout	Issue device clear or local over GPIB or Power ON reset	A5
6	Digit/segments of display not lighting or always lit	Cable W2 malfunction	Check continuity of cable and connector	W2
		IC malfunction	Check digit and segment drivers on A8U1 and A8U2	A8
			Check digit and segment output on A6U13 and A6U8	A6
			Check data output of CPU A4	A4
			Check display connector for improper contact	W2

Table 4-3 Troubleshooting Guide (Continued)

7	Display reading zero in one or both pressure ranges	Loss of CCO frequencies	Check frequencies of both CCO's on interconnect board	A1,A2,A9
			Check +8VDC and -12VDC on interconnect board	A7,A9
		Loss of crystal oscillator frequency to period counter	Check frequency out of crystal oscillator A1, A2	A1,A2
			Check 5VDC power to crystal oscillator	A1,A2,A9
			Check output inhibit of crystal oscillator	A1,A2
		Period counter malfunction	Check input to period counter A3U8 of both frequencies	A3
			Check counter data being strobed on to data bus	A3,A4
8	Display reading does not change in one or both pressure ranges	Loss of CCO frequency or crystal oscillator frequency	Check frequencies out of CCO A1, A2	A1,A2
			Check transducer connections	PT1,PT2 A1,A2
		Program latch up	Power OFF (wait 5 seconds) /ON for power ON reset	A4
		Very stable pressure	N/A	

9	Error code -0-	Bus logic error (GPIB)	Power ON reset	A5,A4
			Check GPIB controller programming	
			Check GPIB instrument addressing	A5,W4
			Send DCL device clear from GPIB controller	
10	Error code -1-, continuous or flashing	Look Up Table address error	Incoming data above highest address in LUT	A1,A2
			Add INDEX and CORRECTION number to next higher address	A1,A2

Table 4-3 Troubleshooting Guide (Continued)

11	Error code -3-	Data conversion overflow	Reject data; allow CPU to cycle several times	A4
			Check incoming data with MODE switch in CALIBRATE position	A3,A4
12	Error code -4-	Bus data error (GPIB)	Reject data; allow CPU to cycle several times	A5,A4
			Send DCL from GPIB controller	
			Power ON reset	A5
13	Error code -5-	Truncation of binary-to-decimal conversion	Reject data; allow CPU to cycle several times	A4
			Power ON reset if code continues	A4
			Check Memory TEST number	A4
14	Error code -7-	Add/Subtract sub-routine overflow	Reject data; allow CPU to cycle several times	A4
			Check Memory TEST number; program storage malfunction	A4
			Check incoming data with MODE switch in CALIBRATE	A3,A4
15	Error code -9-	Loop time error	Program hung up in a loop; Power ON reset	A4
16	Displayed data not the same as GPIB Data	Data buffer not cleared Interrupted GPIB transmission	Reject data; allow CPU and GPIB to cycle	A4
			Reject data; start new GPIB cycle	A4,A5
		Cable failure W3, W4	Check cable connections; Ring out cable leads	W3,W4
		GPIB I/O failure	Check data into A5U11	A5
			Check GPIB line drivers A5U15-A5U18	A5

Table 4-3 Troubleshooting Guide (Continued)

17	Instrument non-responsive to GPIB commands	Incorrect Listen/Talk address	Set correct Listen/Talk address called in program	A5 S1-S5
		Cable failures	Check cable connections	W3,W4
			Ring out cable leads	W3,W4
		Incorrect GPIB board address	Check address bus into A5U1, U2, U3	A5
		GPIB sub routine in program	Check Memory TEST for proper number	A4
		I/O failure	Check data (commands) into A5U11	A5
			Check data and control line drivers A5U15-A5U18	A5
18	Instability of display	Unstable or changing pressure	Stabilize pressure source; allow time for temperature to equilibrate	
		Pressure leak (in OR out)	Check for pressure leaks in tubing and valves	
		Frequency not in LOCK	Check zero pressure frequency 400-450KHZ	A1,A2,19
			Check TP4 for $\pm$ 1/2 V to $\pm$ 1 V spikes to 30-45 KHZ	A1,A2
			Check TP2, TP3 for -12 V sq. wave-compliments	A1,A2
			Check TP5 for $<\pm$5mV at zero psi <-200mV at full scale	A1,A2
			Check for completed ground from transducers	PT1,A1 PT2,A2

Table 4-4 Error Code Listing

DISPLAY ERROR CODE	GPIB SERVICE REQUEST OUT (Hexadecimal)	DESCRIPTION
-0-	61	Acceptor handshake interrupt when neither ATN line TRUE nor addressed as listener.
-1-	64	Lookup table index values are all less than value to be used.
-3-	6C	Decimal to binary or binary to decimal overflow. Decimal number does not fit in 23 bits of binary or binary number requires more digits than specified.
-4-	70	Data buffers are both empty; next character or buss is meaningless. (When SRQ is executed, the character will probably have been received).
-5-	74	The storage area for BCD data is insufficient so data was truncated, filling available length.
-7-	7C	During addition or subtraction of numbers an overflow occurred; i.e., the result is greater than 23 bits. Sign of result different from operands.
-9-	64	Too long waiting for data ready flag from counter.

4.7 DISASSEMBLY AND ASSEMBLY Disassembly for repair, recalibration adjustments, or cleaning is accomplished as described in the following instructions.

WARNING

Disconnect power before performing repairs.

4.7.1 Instrument Chassis Remove instrument from case as follows:

1. Disconnect power and GPIB cables.
2. Remove six (6) screws from front panel.
3. Lift instrument out of case. Caution is required to avoid catching service legs and I/O ribbon cables on lip of case.
4. Reassemble in reverse order.

4.7.2 Printed Wire Assembly Cards Remove PWAs from chassis as follows:

1. Remove eight (8) screws and card retainer.
2. Disconnect cables from PWA before removing from card rack.
3. Remove PWA by lifting card extractors on each end of card.
4. Reassemble in reverse order.

4.7.3 Display Assembly Remove display from chassis as follows:

1. Remove six (6) screws from back of display housing.
2. Remove display cover and disengage display housing from base mounted to front panel.
3. Disconnect cable W2 from PWA A8.
4. Remove four (4) screws holding PWA A8 to display.
5. Reassemble in reverse order.

4.7.4 Pressure Transducer Disassembly of pressure transducer should only be performed by trained service technicians.

Range 1: 10K psig Transducer

1. Disconnect cables from PWA A1. Unsolder ground lug.
2. Remove three (3) screws from end cover and remove end cover by pulling straight out (O-ring seal).
3. Remove six (6) cap screws holding base to pressure housing.
4. Remove base and pressure element carefully from pressure housing, allowing as much room as possible on the cable stuffing tube side of the pressure element. This is to

allow clearance for the thermistor mounted on the pressure element.

5. Reassemble in reverse order.
6. Torque cap screws in step 3 above to 15 ft-lbs.

Range 2: 1K psig Transducer

1. Disconnect cables from PWA A2. Unsolder ground lug.
2. Remove four (4) screws from end cover and remove end cover by pulling straight out (O-ring seal).
3. Remove eight (8) cap screws holding base to pressure housing.
4. Remove base and pressure element carefully from pressure housing, allowing as much room as possible on the cable stuffing tube side of the pressure element. This is to allow clearance for the thermistor mounted on the pressure element.
5. Reassemble in reverse order.
6. Torque cap screws in step 3 above to 7 ft-lbs.

4.8 CLEANING Cleaning of the instrument may be required periodically.

4.8.1 Instrument in General

1. Dust caps should always be installed when a pressure port is not in use. Clean the pressure ports with a Q-tip dipped in a solvent such as isopropyl alcohol. Wipe the inside of the port and threads.
2. Use a solvent (isopropyl alcohol) soaked "Chem-wipe" to clean the front panel and display. A Q-tip may be used to clean the recessed power cord socket.

4.8.2 Printed Wire Assembly The only cleaning that might be required on the PWAs is the edge cord connector.

1. Remove PWA from card rack.
2. Clean tarnish from gold plated contacts with appropriate solvent or soft rubber eraser. Clean grease and

fingerprint oils from contacts with solvent such as isopropyl alcohol.

4.8.3 Transducer The transducer may be cleaned by one of two methods. Cleaning can be accomplished by disassembly and parts cleaning or flushing by vacuum and backfilling with solvent through the pressure port. Isopropyl alcohol is the only solvent recommended for cleaning the transducers. If other solvents, such as Freon, are used for cleaning, they should be used sparingly and allowed to dry immediately. The flushing method risks removing the O-ring grease in the transducer and developing pressure leaks.

4.9 RECALIBRATION ADJUSTMENTS Recalibration of the Model PTS-102 consists of two parts: temperature compensation and linearization. Linearization may be performed without readjusting temperature compensation; but if temperature compensation needs to be readjusted, it is likely that linearization must be performed. Temperature compensation offsets the effect of ambient temperature and adiabatic heating or cooling (due to pressure changes), and is applied directly to the CCO frequency. Linearization of pressure reading is from a set of correction values in a Look Up Table (LUT), added to the raw data coming from the CCO and Period Counter.

WARNING

High pressure gas at 10,000 psi used with this instrument may cause injury if discharged against the skin and especially the eyes. Do not use oxygen in this instrument. It has not been cleaned for oxygen use.

4.9.1 Recommended Equipment Refer to Par. 4.4 for recommended test and calibration equipment.

4.9.2 Test Configuration The test and recalibration of the Model PTS-102 may be performed using the configuration shown in Figure 4-1 and Figure 4-2.

4.9.3 Transducer Exercise At the beginning of instrument calibration, or if the instrument has been setting at zero pressure for one or more hours, the pressure transducer must be exercised three (3) times over the full pressure range to assure there will be no zero offset to the data.

4.9.4 Test Comparison The test comparison is performed to determine if the instrument is still within accuracy specification.

1. Set up test configuration as shown in Figure 4-1.
2. Allow 1 hour warm up time.
3. Exercise pressure range 0 to full scale three (3) times (slowly).
4. Press ZERO reset switch.
5. Record pressure reading at zero pressure and for each 10% of range generated by the piston gauge. Record pressure reading at each 10% of range decreasing from full scale to zero.

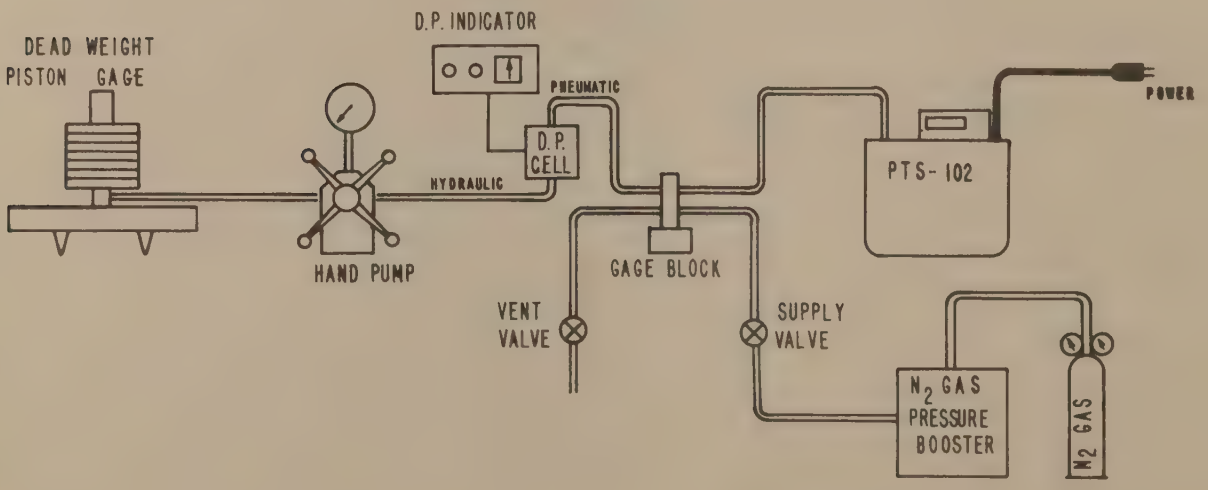


Figure 4-1 Test Configuration

6. Slow pressure changes will produce more accurate and stable readings.
7. Compare indicated value of pressure with the actual pressure generated by the piston gauge and determine if it is within specification.

4.9.5 Temperature Compensation Evaluation Temperature compensation is evaluated by taking data as described in Par. 4.9.4 above except that the environmental chamber is used as shown in test configuration Figure 4-2. The data is taken at two or three temperatures.

1. Set up test configuration with environmental chamber as shown in Figure 4-2.
2. Set chamber to 15°C (59°).
3. Allow one to two hours for temperature to equilibrate within the instrument.
4. Record data as described in steps 3, 4, and 5 in Par.4.9.4.
5. Repeat steps 3 and 4 above at 25°C and 35°C as required.
6. Compare data from each temperature run to the generated piston gage pressure. If data is out of specification, follow the procedure of Par. 4.9.6.

4.9.6 Temperature Compensation Adjustment rocedure To adjust temperature compensation the instrument must be removed from the case and laid on its side in the chamber as shown in Figure 4-2. With the instrument out of the case, the chamber temperatures should be 25°C, 35°C, and 45°C to account for the temperature rise when the instrument was inside the case.

1. Test configuration set up as shown in Figure 4-2.
2. Connect frequency counter test probe to appropriate frequency output pin on Interconnect PWA, A9.
3. Allow one hour initial warm up at 25°C.
4. Exercise instrument over full scale pressure range three (3) times or more until zero pressure frequency repeats.
5. Component drifts may cause a shift from the initial TC network setup. Check the following test points

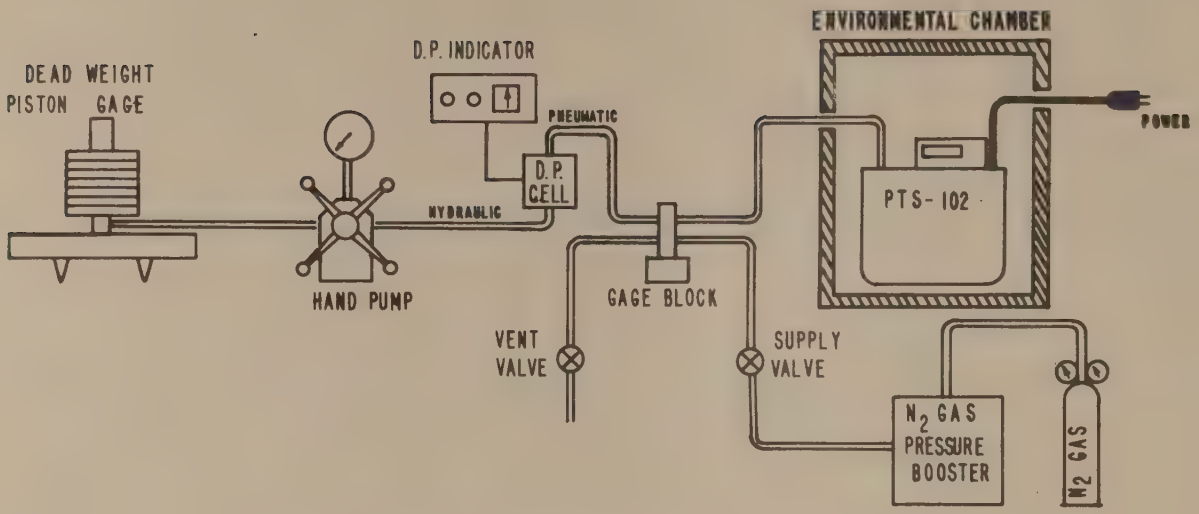


Figure 4-2 Temperature Compensation Test Configuration

(Figure 5-4) at 25°C and make adjustments as required:

a. TP7 - Thermistor bridge balance at 25°C. Should be less than 1 mV at zero pressure and 25°C environmental chamber temperature. Adjust Yo (R41) as required.

b. TP8 - Pressure dependent voltage, Vo. Should be 0.00 mV at zero pressure. Adjust Vo (R26) as required.

c. TP6 - Used during initial set up of TC network. Monitors curvature voltage, but not required after initial set up.

d. TP5 - Monitors the temperature compensating voltage, Vtc, applied to the frequency loop integrators. Should be less than ±2mV at zero pressure and 25°C and roughly -200mV at full scale pressure at 45°C.

6. Apply pressure from piston gauge and record frequency at 0, 40%, and 100% of range.

7. Set chamber temperature to 45°C and allow one hour or more for temperature stabilization.

8. Repeat steps 4 and 6. Frequencies should be identical.

$$C = 10^5 \times \frac{f}{f_0 - f_{100}} \qquad (4\text{-}1)$$

Where:

C = counts, equivalent counts of display reading

10^5 = maximum counts of display at full scale

f = frequency difference with respect to hysteresis or temperature change.

f_0 = frequency at zero pressure

f_{100} = frequency at 100% of full scale

The relationship of equivalent display counts to the specification is: $\pm$10 counts from zero to 20% of range and then increasing by $\pm$5 counts each 10% of range to a maximum of $\pm$50 counts at 100% of range.

9. Frequency data recorded at 25°C and 45°C may have an offset between the zero pressure readings. Subtract the 25°C from the 45°C zero pressure frequency. This is the zero offset and then add the zero offset to the 40% and 100% frequencies at 25°C. The calculated frequencies are the ideal 40% and 100% values at 45°C. The temperature compensation error is the difference between the ideal (with zero offset) at 45°C and the actual data at 45°C.

10. If zero offset is very large (greater than 100 Hz) then adjust R32 Atc potentiometer (chamber is at 45°C) so that zero pressure reading at 45°C is identical to the reading at 25°C. If this adjustment is made, then the ideal values for 40% and 100% are the 25°C frequency value.

11. While the chamber is at 45°C, increase pressure to 40% of range and adjust Ytc potentiometer (R34) for the ideal value at 40%. This is a linear adjust and will shift the 100% reading by about 2.5 times the amount of adjustment made at 40%.

12. While the chamber is at 45°C, increase the pressure to 100% of range and adjust the curvature pot C (R51) for the ideal value at 100%. This is a cubic (3rd order) correction and will change the reading at 40% by approximately 1/16 of the value of change made at 100% of range.

13. While the chamber is at 45°C, decrease pressure to zero psig and read frequency when stable. Calculate new ideal

numbers as per steps 8 and 9 for 40% and 100% of range points using the new zero offset if the frequency at zero psig has changed.

14. Repeat steps 11 and 12 with chamber at 45°C and make adjustments as required.
15. Set chamber temperature to 25°C and allow one hour or more for temperature equalization.
16. Repeat steps 4 and 6 with chamber at 25°C.
17. If frequency variation between 45°C and 25°C readings is within specification as determined by equation 4-1, proceed to Look Up Table calibration procedure 4.8. If frequency data is not within specification, repeat steps 4 through 16 until it is within specification.

4.10 LOOK UP TABLE The Look Up Table (LUT) of pressure correction values are contained in a Programmable Read Only Memory (PROM). During calibration the LUT can be bypassed by setting the MODE switch (A9S1 on Interconnect PWA) to the CALIBRATE position. This provides raw data to the display which is used in determining the point of correction or Index Number. The LUT consists of F_0 numbers, Index Numbers, and their corresponding Correction Numbers in alternating serial order as shown in Figure 4-3 (i.e., Index Number, Correction Number, Index Number, Correction Number, etc.)

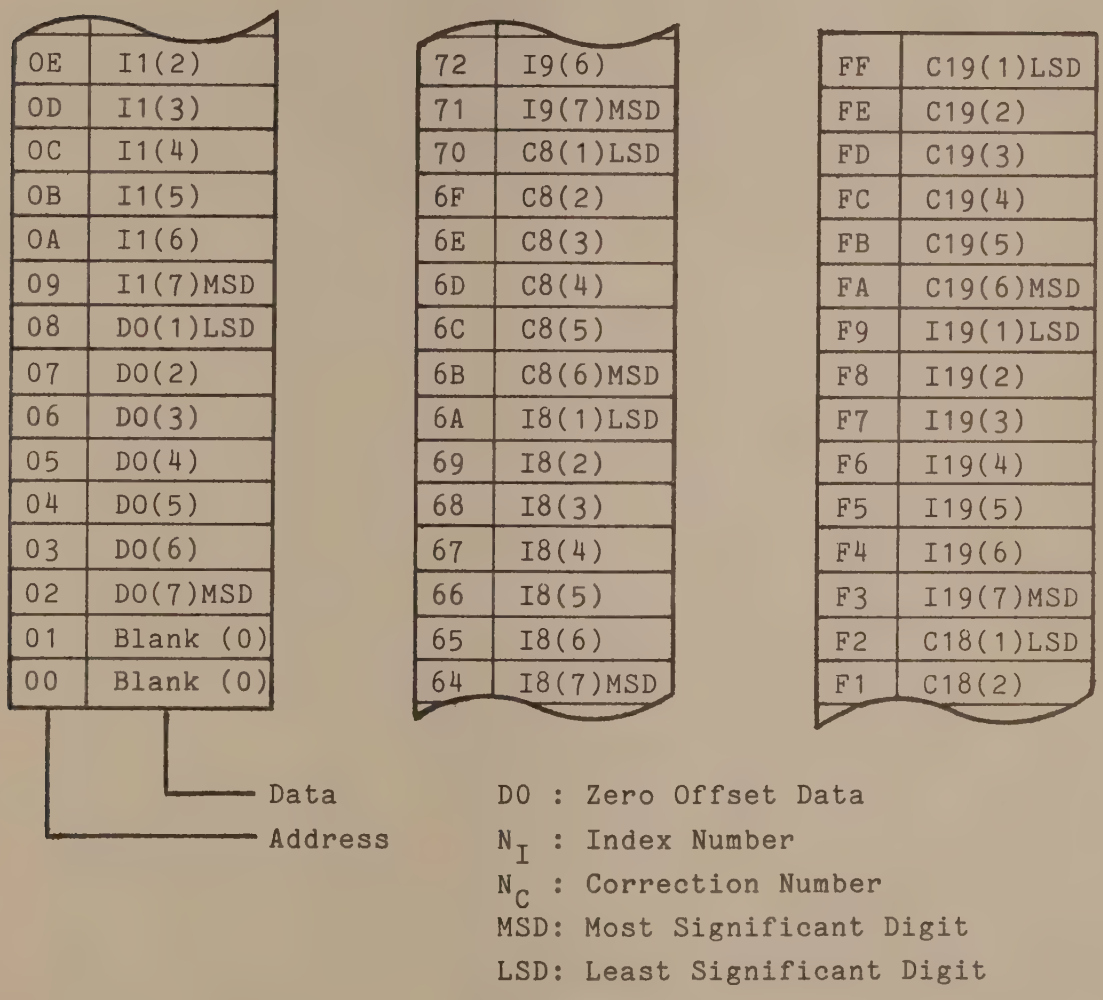
4.10.1 Index Numbers The Index Number is similar to an address. It is derived from the raw, uncorrected data displayed when the MODE Switch is in CALIBRATE. In order to lessen the effect of hysteresis, the Index Number for each pressure point put into the LUT should be the numerical average between the raw data of the increasing pressure run and the raw data of the decreasing pressure run.

4.10.2 Correction Numbers The Correction Number for a specific Index Number is the algebraic difference between the Actual Pressure and the Index Number at the same pressure point.

4.10.3 LUT Storage Calibration data in the form of Index Numbers and Correction Numbers are placed in a PROM for permanent, non-

volatile storage. The PROM is programmed by the Data I/O Model IX programmer or equivalent. The PROM is then placed in the LUT socket (U16) of its respective CCO.

Figure 4-3 LUT Organization



DO : Zero Offset Data
N_I : Index Number
N_C : Correction Number
MSD: Most Significant Digit
LSD: Least Significant Digit

4.11 LUT GENERATION AND MODIFICATION The above description of the LUT and the data that make up the LUT is similar to one of the two methods of generating the table. The second method is LUT or PROM Emulation.

4.11.1 Data Reduction One method of generating the Look Up Table is described in the following procedure with old PROM installed:

1. Set the MODE Switch to CALIBRATE. Old F_0 number in old PROM.
2. Exercise the pressure range three (3) or more times for good zero pressure reading repeatability.
3. Make a pressure data run of both increasing and decreasing pressure points for as many points as are desired in the LUT. Always include one LUT point out beyond full scale (105% or 110% of range) to allow stable data beyond full scale. Record data with the MODE switch in CALIBRATE. Record actual pressure calculated for the piston gauge at each point.
4. Data reduction consists of calculating Index and Correction Numbers.

$$N_I = \left[F_0 - \frac{D_i + D_d}{2}\right] * A \qquad (4\text{-}2)$$

$$N_C = P_a * A - N_I \qquad (4\text{-}3)$$

Where: N_I = Index Number
F_0 = Data, Zero pressure
D_i = Data, increasing pressure
D_d = Data, decreasing pressure
N_C = Correction Number
P_a = Actual pressure

For 1K psig range, A = 1000
For 10K psig range, A = 100

Refer to Par. 4.12.2 for additional restrictions on number length and conversion of negative value Correction Numbers.

CAUTION

The CMOS PROM is subject to damage by static discharge. Ground yourself before handling.

5. The values of N_I and N_C for each pressure point and F_0 at zero pressure are then entered into the PROM programmer memory in sequential order as per the LUT Address Table 4-5. Verify the data in memory and then program the PROM (Harris Semiconductor Part No. HM1-6611-9).

Table 4-5 LUT Addresses

Frequency Offset Address: 02 to 08		
LUT POINT	INDEX ADDRESS (HEXIDECIMAL)	CORRECTION ADDRESS (HEXIDECIMAL)
1	09-0F	10-15
2	16-1C	1D-22
3	23-29	2A-2F
4	30-36	37-3C
5	3D-43	44-49
6	4A-50	51-56
7	57-5D	5E-63
8	64-6A	6B-70
9	71-77	78-7D
10	7E-84	85-8A
11	8B-91	92-97
12	98-9E	9F-A4
13	A5-AB	AC-B1
14	B2-B8	B9-BE
15	BF-C5	C6-CB
16	CC-D2	D3-D8
17	D9-DF	E0-E5
18	E6-EC	ED-F2
19	F3-F9	FA-FF

6. Place the PROM in socket U16 of the appropriate CCO (make sure power is OFF).
7. Make a pressure data run with the MODE switch in OPERATE. Data should be taken at each pressure point that is in the

LUT and at the pressure midway between each point in the LUT. If data errors are out of specification between table points, an additional table point must be added. This requires the following:

a. Calculate N_I and N_C for the new point.
b. Repeat steps 5 and 6 to insert the new point in sequential order. Program a new PROM.

4.11.2 LUT Emulation The second method of LUT generation is by emulating the PROM Look Up Table, which is described in the following procedure:

1. Set the MODE Switch to CALIBRATE.
2. Connect a PROM emulator, such as the DATA I/O ROMULATOR and RAM-PAK, into socket U16 of the appropriate CCO for the pressure range being calibrated. PROM to be emulated is the Harris Semiconductor, HM1-6611-9(256x4 configuration).
3. Exercise the pressure range three (3) or more times for good zero pressure reading repeatability.
4. Measure the CCO frequency (TP1) at zero pressure. Multiply this frequency reading by six and enter (F_0) into address 02 as shown in Table 4-5 and Figure 4-3. Change F_0 as required to produce a display reading of zero.
5. Index Numbers and Correction Numbers may be entered into the LUT emulator at each pressure point. With F_0 entered into the LUT, the display reads the Index Number direct. The Index Number should be adjusted for the hysteresis reading on the decreasing pressure run. The Correction Number is then calculated from the actual pressure and the average Index Number as in equation 4-3. Enter Index and Correction Numbers in sequence, as shown in Address Table 4-5.
6. Set MODE switch to OPERATE.
7. Make a pressure data run, recording display data at each LUT point and one pressure point in between the LUT points. At each LUT point, an adjustment to the Correction Number may be made as required, but make allowance for the amount

and sign of the hysteresis that will be seen on the decreasing pressure run.

8. When the data in the LUT emulator has been determined to provide display reading within specification, the emulator data should be transfered to a PROM programmer such as the DATA I/O Model IX. When the data is verified, program the Harris Semiconductor, HM1-6611-9 PROM.

CAUTION

Static discharge will damage the CMOS PROM. Ground yourself before handling PROM.

9. Install the LUT PROM in socket U16 of the appropriate CCO, and make a pressure data run to check calibration.

4.11.3 LUT Generation Variations Several variations to the two LUT generation procedures described above are possible.

1. For recalibration when data errors are small, leave the LUT PROM in its socket and make the pressure data run. Calculate the CHANGE required at each LUT point. Calculate the new Correction Number required. This approach would maintain the same Index Numbers. Verify data and program a new PROM.
2. Take pressure and Index data as in Par. 4.11.1 but enter it into an emulator as in Par. 4.11.2. Test and verify data, making adjustments to Index and Correction Numbers in the emulator. Program PROM as per Address Table 4-5.

4.12 PROM PROGRAMING Programing of the PROM must be done EXACTLY as described in the following procedure in order to present the necessary data to the microprocessor when requested.

4.12.1 PROM Architecture The PROM used to store the LUT data is the Harris Semiconductor HM1-6611-9. It is a CMOS IC Memory of 256 characters that are four (4) bits wide. Thus, the 4 bit binary number stored in each character may represent one of the 16 hexidecimal numbers (0-9, and A-F) as shown in Table 4-6.

4.12.2 Number Length Each number put into LUT memory has a prescribed length that must be completely filled; that is, all leading zeros are entered. Decimal point is not used with either number. The lengths are as follows:

1. Frequency Offset: Seven (7) characters (F_0 or frequency x 6)
2. Index Number (N_I): Seven (7) characters
3. Correction Number (N_C): Six (6) characters.

The Correction Number is the only one that may be negative. To represent a negative Correction Number in the LUT, add 800000 to the required value. Thus, if a hexidecimal 8 to F is in the most significant digit (MSD) of the Correction Number, it represents a negative number. Two examples are:

Correction Number is -1500:

```
  1500
800000
801500 stored in LUT
```

Correction Number is -201500:

```
201500
800000
A01500
```

In the second case the summation of 8+2 is a hexidecimal A and the number length remains at six (6) instead of requiring 7 characters. Number conversions are shown in Table 4-6.

4.12.3 LUT Addressing Addressing of the LUT by the microprocessor provides for an orderly retrieval of data upon request. The LUT addresses are shown in Table 4-5 and the LUT organization is shown in Figure 4-3.

The maximum size of the LUT is 19 points due to the lengths of the numbers. The Frequency Offset number utilizes 7 characters; the Index Number utilizes 133 characters; and the Correction Number utilizes 114, for a total of 254 characters out of 256.

Table 4-6 Number Conversions

DECIMAL	HEXIDECIMAL	BINARY
0	0	0000
1	1	0001
2	2	0010
3	3	0011
4	4	0100
5	5	0101
6	6	0110
7	7	0111
8	8	1000
9	9	1001
10	A	1010
11	B	1011
12	C	1100
13	D	1101
14	E	1110
15	F	1111

THIS PAGE LEFT BLANK

SECTION V
ILLUSTRATED PARTS LISTS

5.1 INTRODUCTION This section contains tabulation and illustrations of the major components and printed wire assemblies for the Model PTS-102. Included also are manufacturer source codes and recommended spare parts.

5.2 PARTS LIST FORMAT The Illustrated Parts List is arranged in a six (6) column format.

1. FIG: Provides reference to the figure that illustrates the assembly where part is used.
2. REF DESIG: Reference designator of part, where applicable.
3. PART NUMBER: The manufacturer's or MGC's part number to be used when ordering replacement parts.
4. DESCRIPTION: The name of the part.
5. FSCM: Federal Supply Code of Manufacturer's number used to identify the manufacturer.
6. QTY: Quantity of that specific part used on that assembly.

5.3 ORDERING INFORMATION To facilitate the shipment of replacement parts from the factory, it is necessary that the Model and Serial numbers of the instrument be included along with the Part Number and Description of the component on the purchase order. If PROM IC's are to be programmed at factory, send data (in hexidecimal format) along with order. Data should be formatted as shown in the PROM Address Tables 4-4 and 4-5.

5.4 FSCM CODE NUMBER TO MANUFACTURER'S NAME The following list in Table 5-1 converts FSCM Number to Manufacturer's name and location.

Table 5-1 FSCM Code to Name Conversion

FSCM	MANUFACTURER	LOCATION
00000	U.S.A. Common	Any Supplier of USA
02580	Swagelok/Crawford Fitting Co.	Solon, OH 44139
02660	Amphenol/Bunker Ramo Corp.	Broadview, IL 60153
02735	RCA	Somerville, NJ 08876
04190	Pneu-Hydro	Rockaway, NJ 07866
04713	Motorola Semi. Prod., Inc.	Phoenix, AR 85036
05245	Corcom, Inc.	Chicago, IL 60639
07263	Fairchild Semiconductor	Mt. View, CA 94042
07644	Halocarbon Products Corp.	Hackensack, NJ 07601
09021	Airco-Speer Electronics	Bradford, PA 16701
11769	Elco Corp.	El Segundo, CA 90245
12324	Stake/Dupree, Inc.	El Monte, CA 91733
15801	Fenwal Electronics, Inc.	Framingham, MA 01701
17856	Siliconix, Inc.	Santa Clara, CA 95054
18324	Signetics Corp.	Sunnyvale, CA 94086
18612	Vishay Resistor Products	Malvern, PA 19355
18677	Scambe/Canoga Industries,	El Monte, CA 91731
22526	Berg Electronics	New Cumberland, PA 17070
23880	SAE, Inc.	Santa Clara, CA 95050
25088	Siemens Corp.	Iselin, NJ 08830
27014	National Semiconductor Corp.	Santa Clara, CA 95051
27264	Molex, Inc.	Lisle, IL 60532
27802	Vectron Laboratory,	Norwalk, CT 06854
28117	Micro Power International, Inc.	San Diego, CA 92126
28480	Hewlett-Packard Co.	Palo Alto, CA 94304
34371	Harris Semiconductor	Melbourne, FL 32901
46384	Pem/Penn Eng. & Mfg. Corp.	Doylestown, PA 18901
50829	Semiconductor Circuits Corp.	Haverhill, MA 01830
52063	Exar Integrated Systems, Inc.	Sunnyvale, CA 94088
54961	Metrology General Corp.	San Diego, CA 92123
56289	Sprague Products Co.	North Adams, MA 01247
59730	Thomas & Betts	Elizabeth, NJ 07207
71400	Bussman Mfg.	St. Louis, MO 63107
71785	TRW/Cinch	Elk Grove Village, IL 60007
75915	Littelfuse, Inc.	Des Plains, IL 60016
80031	Mepco/Electra Products	Morristown, NJ 07960
81073	Grayhill, Inc.	La Grange, IL 60525
83259	Parker Seal Co.	Culver City, CA 90230
83330	H. H. Smith	Brooklyn, NY 11207
82389	Switchcraft, Inc.	Chicago, IL 60630
83594	Burroughs Corp.	Plainfield, NJ 07061
86928	Seastrom	Glendale, CA 91201
88245	Useco/Litton Industries	Van Nuys, CA 91409
92194	Alpha Wire Corp.	Elizabeth, NJ 07207
95146	Alco Electronics Products, Inc.	No. Andover, MA 01845
98278	Malco/Microdot Corp.	Pasadena, CA 91030
98291	Sealectro Corp.	Mamaroneck, NY 10543
-	Alpha Power, Inc.	Canoga Park, CA 91304
-	Endicott Coil Corp.	Binghamton, NY 13905

5.5 RECOMMENDED SPARE PARTS Spare parts recommended for maintenance of the PTS-102 are listed at the three levels that are common to most operating laboratories and their maintenance facilities.

Level 1: Operator level of maintenance at the point of use.

Level 2: Intermediate level of maintenance at a service center staffed with electronic technicians capable of troubleshooting at the board or assembly level.

Level 3: Repair Depot level of maintenance at a major repair depot with electronic technicians and equipment to perform recalibration and component level troubleshooting.

5.5.1 Level 1 Recommended Spare Parts Level 1, Table 5-2, recommended spare parts are intended to support one Model PTS-102 in the field for one year.

Table 5-2 Level 1 Recommended Spare Parts

FIG	REF DESIG	PART NUMBER	DESCRIPTION	FSCM	QTY
5-2	A1F1	3AG-1/2A	FUSE	75915	5
5-1		2329-1	DUST CAP	54961	1
5-1		2329-2	DUST CAP	54961	1
	A1W1	80-1245	CABLE, POWER	82389	1

5.5.2 Level 2 Recommended Spare Parts Level 2, Table 5-3, recommended spare parts are intended to support up to five (5) Model PTS-102 instruments at an appropriate service center.

Table 5-3 Level 2 Recommended Spare Parts

FIG	REF DESIG	PART NUMBER	DESCRIPTION	FSCM	QTY
5-2	F1	3AG-1/2A	FUSE	75915	10
5-1		2329-1	DUST CAP	54961	2
5-1		2329-2	DUST CAP	54961	2
	A1W1	80-1245	CABLE, POWER	82389	1
5-3	A1W2	2369-1	CABLE, DISPLAY	54961	1
5-3	A1W3	2368-1	CABLE, GPIB	54961	1
5-3,5	A1A3	2343-1	PWA, CENTR	54961	1
5-3,6	A1A4	2355-1	PWA, CPU	54961	1
5-3,7	A1A5	2352-1	PWA, GPIB	54961	1
5-3,8	A1A6	2349-1	PWA, DECODER/MUX	54961	1
5-3,9	A1A7	2362-1	PWA, POWER SUPPLY	54961	1
5-10	A1A8	2366-1	ASSEMBLY, DISPLAY	54961	1
5-2	A1S1	80-02-09-501A-6163	SWITCH, POWER	81073	1
5-1		Z569	RELIEF VALVE	04190	1
5-2		3EF1	FILTER, POWER LINE	05245	1
5-11		2376-1	BLOCKING VALVE ASSY.	54961	1

5.5.3 Level 3 Recommended Spare Parts Level 3, Table 5-4, recommended spare parts are intended to support up to ten (10) Model PTS-102 instruments at a major repair and calibration depot.

Table 5-4 Level 3 Recommended Spare Parts

FIG	REF DESIG	PART NUMBER	DESCRIPTION	FSCM	QTY
5-8	A1A6	2349-1	PWA, DECODER/MUX	54961	1
5-9	A1A7	2362-1	PWA, POWER SUPPLY	54961	1
		23626-1	RETAINER, PWB	54961	1
5-3	A1W2	2369-1	CABLE, DISPLAY	54961	4
5-3	A1W3	2368-1	CABLE, GPIB	54961	4
		2-122-V747-75	O-RING, 10K PSIG XDUCER	83259	10
		2-125-V747-75	O-RING, 1K PSIG XDUCER	83259	10
		25-5S	O-RING LUB., HALOCARBON 2 OZ. TUBES	07644	2
5-1		Z569	RELIEF VALVE	04190	1
	A1PT1J1J2	51-328-3196	CONN., RT. ANG., COAXIAL	98291	2
5-3	A1PT1J3	09-50-3021	CONN., 3 WIRE	27264	4
5-1		08-50-0108	PIN, CONN.	27264	12
		1.75 x 1/4-28	SCREW, HEX SOCKET	00000	6
		1.50 x 10-32	SCREW, HEX SOCKET	00000	8
		5702-245-10	WASHER	86928	6
		5702-85-18	WASHER	86928	8
5-9	A1A7U1	1C5	POWER SUPPLY +5V	ALPHA POWER	1
5-9	A1A7U2	920-12-8	POWER SUPPLY +8V,-12V	28117	1
	A1A9J1J7	SCC 22/D2-2	CONN., 44 PIN	23880	2
5-1	A1A9S1	7101A	SWITCH, MODE	95146	1
5-1	A1A8S1	82-101-71	SWITCH, RANGE	81073	1
5-1	A1A8S2	39-1	SWITCH, TEST	81073	2
5-1	A1A8S3	39-3	SWITCH, ZERO	81073	2
5-10	A1A8SP1	E705-215UCT	POWER SUPPLY +100VDC	ENDICOTT	1
	VARIOUS	F4001PC	IC, CMOS GATE	07263	4
		F4007PC	IC, CMOS COMP. PAIR	07263	8
		F4011PC	IC, CMOS GATE	07263	8
		F4013PC	IC, CMOS D F/F	07263	4
		F4025PC	IC, CMOS GATE	07263	4
		F4027PC	IC, CMOS J-K F/F	07263	2
		F4028PC	IC, CMOS BCD/D DECODER	07263	4
		F4040PC	IC, CMOS COUNTER	07263	4
		F4063PC	IC, CMOS COMPARATOR	07263	2
		F4076PC	IC, CMOS TRI-STATE LATCH	07263	8
		F4724PC	IC, CMOS ADDRESSABLE LATCH	07263	2
		MC3440P	IC, GPIB TRANSCEIVER	04713	4
		MC3441P	IC, GPIB TRANSCEIVER	04713	4
		MC14558P	IC, CMOS BCD-7 SEGMENT	04713	2
		CD40208BE	IC, CMOS MULTIPORT	02735	4
5-6	A1A4	CDP1802CD	IC, CMOS MICROPROCESSOR	02735	2
		MC74C42	IC, CMOS BCD-D DECODER	27014	4
5-10	A1A8	NE584-8N	IC, DRIVER	18234	2
5-10	A1A8	NE585-9N	IC, DRIVER	18234	2
5-7	A1A5	N82S100N	IC, FPLA (PRE PROGRAMMED)	18234	2
5-6	A1A4	N82S185N	IC, BIPOLAR PROM (LO) (")	18234	2
5-6	A1A4	N82S185N	IC, BIPOLAR PROM (HI) (")	18234	2
5-6	A1A4	HM1-6562-9	IC, CMOS RAM	34371	4
5-4	A1A1,2	HM1-6611-9	IC, CMOS MEMORY (UNPROGRAMMED)	34371	10
5-10	A1A8CR2	5082-4584	LED, YELLOW	28480	2
5-10	A1A8CR1	5082-4684	LED, RED	28480	2
5-10	A1A8CR3	5082-4984	LED, GREEN	28480	2

Table 5-4 Level 3 Recommended Spare Parts (Continued)

FIG	REF DESIG	PART NUMBER	DESCRIPTION	FSCM	QTY
5-2	A1F1	3AG-1/2A	FUSE	75915	20
5-1		2329-1	DUST CAP	54961	2
5-1		2329-2	DUST CAP	54961	2
5-1		2328-1	CHAIN, RETAINER	54961	2
5-2		80-1245	CABLE, POWER	82389	2
5-2	A1S1	80-02-09-501A-6163	SWITCH, POWER	81073	2
5-2	A1FL1	3EF1	FILTER, POWER LINE	05245	1
5-5	A1A3	2343-1	PWA, CNTR	54961	1
5-6	A1A4	2355-1	PWA, CPU	54961	1
5-7	A1A5	2352-1	PWA, GPIB	54961	1

5.6 ILLUSTRATED PARTS LISTS Illustrated parts lists are included in Tables 5-5 to 5-15 and Figures 5-1 to 5-11.

Table 5-5 Pressure Transfer Standard

FIG	REF DESIG	PART NUMBER	DESCRIPTION	FSCM	QTY
1-1	A1	2367-1	ASSY., PRESSURE TRANSFER STANDARD MODEL PTS-102		
5-1	A1PT2	2300-1	1K PSIG TRANSDUCER	54961	1
		5/8 x 1/4-28	SCREW, HEX SOCKET	00000	6
5-1	A1PT1	2308-1	10K PSIG TRANSDUCER	54961	1
		2318-1	SERVICE LEG	54961	4
		2329-1,-2	DUST CAP	54961	2
		2328-1	RETAINER CHAIN	54961	2
		1072-13	HANDLE, BOW	88245	2
		903-13	FERRULE	88245	4
		HTA	FUSE HOLDER	71400	1
	A1F1	3AG-1/2A	FUSE	75915	1
	A1S1	80-02-09-501A-6163	POWER SWITCH	81073	1
	A1J1	3EF1	CONNECTOR, POWER LINE FILTER	05245	1
	A1W3	2368-1	CABLE, GPIB	54961	1
		57-20240	CONNECTOR	02660	1
		408-14647-5	SCREW	02660	2
		(1505-A Alternate)		(88245)	
5-3,4	A1A1	2340-1	PWA, CCO	54961	1
5-3,4	A1A2	2340-2	PWA, CCO	54961	1
5-3,5	A1A3	2343-1	PWA, PERIOD COUNTER	54961	1
5-3,6	A1A4	2355-1	PWA, CPU	54961	1
5-3,7	A1A5	2352-1	PWA, GPIB	54961	1
5-3,8	A1A6	2349-1	PWA, DECODER/MUX	54961	1
5-3,9	A1A7	2362-1	PWA, POWER SUPPLY	54961	1
		2326-1	PWA RETAINER	54961	1
		4-40 x 5/16 LG	SCREW, PAN HEAD, PHILLIPS	00000	8
	A1A9	2358-1	PWA, INTERCONNECT	54961	1
5-3	A1W2	2369-1	CABLE, DISPLAY	54961	1
5-1,2		2366-1	ASSEMBLY, DISPLAY	54961	1
5-10	A1A8	2346-1	PWA, DISPAY	54961	1
		3/8 x 4-40	SCREW, PAN HEAD, PHILLIPS	00000	2
	A1W1	80-1245	CABLE, POWER		1
			MANUAL	54961	1
		2380-1	CASE	54961	1
5-1		2339-1	PROTECTIVE PLATE	54961	1

Table 5-6 Assembly - Pressure Transducer 10K PSIG

FIG	REF DESIG	PART NUMBER	DESCRIPTION	FSCM	QTY
5-1	PT1	2308	ASSY., PRESSURE TRANSDUCER 10K PSIG		
		A-400-1-2	SWAGE-LOK FITTING	02580	1
		NY-403-1	FERRULE	02580	1
		2-122-V747-75	O'RING	83259	1
		GB41J1	THERMISTOR	15801	1
		5702-245-10	WASHER	86928	6
		1-3/4 x 1/4-28	SCREW, HEX SOCKET CAP	00000	6
		2293-1	COVER	54961	1
		3/8 x 4-40	SCREW	00000	3
		2-023-N674-70	O'RING	83259	1
		2294-1	PRESSURE FITTING	54961	1
		51-328-3196	PLUG, RIGHT ANGLE	98291	2
		09-50-3031	CONNECTOR	27264	1

Table 5-7 Assembly - Pressure Transducer 1K PSIG

FIG	REF DESIG	PART NUMBER	DESCRIPTION	FSCM	QTY
5-1	PT2	2300	ASSY., PRESSURE TRANSDUCER 1K PSIG		
		A-400-1-2	SWAGE-LOK FITTING	02580	1
		NY-403-1	FERRUL	02580	1
		2-125-V747-75	O'RING	83259	1
		GB41J1	THERMISTOR	15801	1
		5702-85-18	WASHER	80928	8
		1-1/2 x 10-32	SCREW, HEX SOCKET CAP	00000	1
		2293-2	COVER	54961	1
		3/8 x 4-40	SCREW	00000	4
		2-023-N674-70	O'RING	83259	1
		2294-1	PRESSURE FITTING	54961	1
		Z569	RELIEF VALVE	04190	1
		1/8" NPT CLOSE	NIPPLE	04190	1
		51-328-3196	PLUG, RIGHT ANGLE	98291	2
		09-50-3031	CONNECTOR	27264	1

Table 5-8 PWA - Capacitance Controlled Oscillator

FIG	REF DESIG	PART NUMBER	DESCRIPTION	FSCM	QTY
5-4	A1A1	2340-1	PWA, CCO		
	A1A2	2341-1	PWB	54961	1
	(A1A1 & A1A2 DESIGNATORS NOT REPEATED FOR CLARITY)				
		2330-1	CARD EJECTOR	18677	1
		2330-2	CARD EJECTOR (A1)	18677	1
		2330-3	CARD EJECTOR (A2)	18677	
	U9,10,11 14	LM307N	IC, OP AMPL	27014	4
	U1	LM308AN	IC, OP AMPL	27014	1
	U2	LM318N	IC, OP AMPL	27014	1
	U12,13	CA3080AS	IC, OP AMPL	02735	2
	U4	F4001PC	IC, CMOS GATE	07263	1

Table 5-8 PWA - Capacitance Controlled Oscillator (Continued)

FIG	REF DESIG	PART NUMBER	DESCRIPTION	FSCM	QTY
	U3	F4007PC	IC, CMOS AMPL	07263	1
	U7	F4013	IC, CMOS D F/F	07263	1
	U8	F4015PC	IC, CMOS S/R	07263	1
	U5	XR-2207-CP	IC, VCO	XR52063	1
	U6	F4081PC	IC, CMOS GATE	07263	1
	U15,16	HM1-6611-9	IC, CMOS PROM	34371	1
	Y1	CO-236-3300-4MHZ	XTL CLOCK OSC	27802	1
	C1,2,3,14, 15	196D476x9020PE4	CAPACITOR, TANT, 47uf,20V	56289	5
	C6,9,13	C280-AE/A-100K	CAPACITOR, .1uf	80031	3
	C16	CK05-BX-470K	CAPACITOR, 47pf	00000	1
	C8	CK05BX-220K	CAPACITOR, 22pf	00000	1
	C10	MKM-B-32548-0.1	CAPACITOR, .1uf, 250V	25088	1
	C4,7	MKM-B-32547-.01	CAPACITOR, .01uf, 250V	25088	2
	C5,12	CM05FD101J03	CAPACITOR, 100pf, 500V	00000	1
	C11	CM04FD100J03	CAPACITOR, 10pf, 500V	00000	1
	R26,32,34 41,51	1202Y-20K	POTENTIOMETER, 20K, 5%	18612	5
	R1,2	S102-75K-1%	RESISTOR, m/f, 75K 1%	18612	2
	R7,33,35, 3,40,44, 47,48,56	RN55C1002F	RESISTOR, m/f, 10K 1%	00000	9
	R3,5,45, 46,50	RN55C1003F	RESISTOR, m/f, 100K, 1%	00000	5
	R6,8	RN55C1503F	RESISTOR, m/f,150K, 1%	00000	2
	R36,54	RN55C8252F	RESISTOR, m/f, 825K 1%	00000	2
	R42,43	RN55C4752F	RESISTOR, m/f,47.5K 1%	00000	2
	R25	RN55C3322F	RESISTOR, m/f, 33.2K 1%	00000	1
	R9	RN55C2212F	RESISTOR, m/f, 22.1K 1%	00000	1
	R38,49	RN55C2002F	RESISTOR, m/f, 20K, 1%	00000	2
	R27	RN55C1822F	RESISTOR, m/f, 18.2K 1%	00000	1
	R57	RN55C6811F	RESISTOR, m/f, 6.81K 1%	00000	1
	R13,39,55	RN55C1001F	RESISTOR, m/f 1K, 1%	00000	3
	CR1	1N4148	DIODE	00000	1
	Q1,2,3,	2N4416A	FET	17856	3
	Q5,6,8	2N2907A	TRANSISTOR	00000	3
	Q4	2N2222	TRANSISTOR	00000	1
	Q7	2N2920	TRANSISTOR, DUAL	00000	1
	TP GND	2021C	SOLDER TERMINAL	83330	1
	TP1-8	2008B	SOLDER TERMINAL	83330	8
	J1,2	51-053-0000	CONN. COAX	98291	2
	J3	09-75-1031	CONN.	27264	1
	XU1,2,9-14	IEW3700-8B	SOCKET	23880	8
	XU8	IEW3700-16B	SOCKET	23880	1
	XU3,4,5, 6,7	IEW3700-14B	SOCKET	23880	5
	XU16	TDH-400-16B	SOCKET	23880	1
	J4	6169-16	HEADER	23880	1
	R4,28,29, 30,31	CF 1/4-1M	RESIST. c/f, 1M, 5%	09021	1
	R15-24,43, 44	CF 1/4-100M	RESIST. c/f, 100M 5%	09021	2
	R12	CF 1/4-33K	RESIST. c/f, 33K, 5%	09021	1
	R14	CF 1/4-10K	RESIST. c/f, 10K, 5%	09021	1
	R10,11	CF 1/4-3.3K	RESIST. c/f, 3.3K, 5%	09021	2
	R52,53	(TBD)	RESISTOR/JUMPER		A/R

Table 5-9 PWA Period Counter

FIG	REF DESIG	PART NUMBER	DESCRIPTION	FSCM	QTY
5-5	A1A3	2343-1	PWA, 2 Input Period Counter		
	(A1A3 DESIGNATORS NOT REPEATED FOR CLARITY)				
		2344-1	PWB	54961	1
		2330-1	CARD EJECTOR	18677	1
		2330-4	CARD EJECTOR (A3)	19677	1
	U1-10	F4011 PC*	IC, CMOS GATE	07263	7
	U11	F4012 PC*	IC, CMOS GATE	07263	1
	U17	F4015 PC	IC, CMOS S/R	07263	1
	U1	F4025 PC	IC, CMOS GATE	07263	1
	U12	F4027 PC*	IC, CMOS J-K F/F	07263	1
	U3	F4028 PC	IC, CMOS BCD-D DECODER	07263	1
	U13-16	F4040 PC*	IC, CMOS CNTR.	07263	4
	U18-25	F4076 PC	IC, CMOS TRI STATE LATCH	07263	8
	U2	MM74C42	IC, CMOS BCD-D DECODER	27014	1
	C3	CSR13G475KM	CAPACITOR, TANT, 4.7uf,50V	00000	1
	C1,2,4-6	CK06-BX-104M	CAPACITOR, .1uf 100V	00000	5
	R12-35,37	CF 1/4-100	RESISTOR, c/f, 100, 5%	09021	25
	R1-11	CF 1/4-100K	RESISTOR, c/f, 100K, 5%	09021	11
	R36	CF 1/4-1M	RESISTOR, c/f, 1M, 5%	09021	1
	XU1,4-11	IEW3700-14-B	SOCKET, DIP, 14 PIN	23880	9
	U2,3,12-25	IEW3700-16-B	SOCKET, DIP, 16 PIN	23880	16

*NO SUBSTITUTE

Table 5-10 PWA - CPU

FIG	REF DESIG	PART NUMBER	DESCRIPTION	FSCM	QTY
5-6	A1A4	2355-1	PWA, CPU		
	(A1A4 DESIGNATORS NOT REPEATED FOR CLARITY)				
		2356-1	PWB	54961	1
		2330-1	CARD EJECTOR	18677	1
		2330-5	CARD EJECTOR (A4)	18677	1
	U11	F4001 PC	IC, CMOS GATE	07263	1
	U10	F4012 PC	IC, CMOS GATE	07263	1
	U12	F4013 PC	IC, CMOS D F/F	07263	1
	U6	F4042 PC	IC, CMOS D LATCH	07263	1
	U8,9	F4050 PC	IC, CMOS BUFFER	07263	2
	U7	MM74C42	IC, CMOS BCD-D DECODER	27014	1
	U2,3	N82S185	IC, PROM, BIPOLAR	18324	2
	U4,5	HM6562-9	IC, RAM, CMOS	34371	2
	U1	CDP1802	IC, CPU, CMOS	02735	1
	C6	CSR13G475KM	CAPACITOR, TANT, 4.7uf, 50V	00000	1
	C3-5	CK06BX104M	CAPACITOR, .1uf, 100V	00000	3
	C7	CK05BX360M	CAPACITOR, 36pf, 200V	00000	1
	R1-8	CF 1/4-100 5%	RESISTOR, c/f, 100	09021	8
	R10-25	CF 1/4-100K 5%	RESISTOR, c/f, 100K	09021	16
	R26	CF 1/4-11K	RESISTOR, c/f, 11K	09021	1
	XU10,11,12	IEW3700-14B	SOCKET, DIP, 14PIN	23880	3
	XU4-9	IEW3700-16B	SOCKET, DIP, 16PIN	23880	6
	XU2,3	IEW3700-18B	SOCKET, DIP, 18PIN	23880	2
	XU1	IEW3700-40B	SOCKET, DIP, 40 PIN	23880	1

Table 5-11 PWA - GPIB I/O

FIG	REF DESIG	PART NUMBER	DESCRIPTION	FSCM	QTY
5-7	A1A5	2352-1	PWA, GPIB INTERFACE		
	(A1A5 DESIGNATORS NOT REPEATED FOR CLARITY)				
		2353-1	PWB	54961	1
		2330-1	CARD EJECTOR	18677	1
		2330-6	CARD EJECTOR (A5)	18677	1
	U4	F4001PC	IC, CMOS GATE	07263	1
	U13	F4012PC	IC, CMOS GATE	07263	1
	U12	F4013PC	IC, CMOS D F/F	07263	1
	U5	F4017PC	IC, CMOS CNTR	07263	1
	U19,20	F4050PC	IC, CMOS BUFFER	07263	2
	U1	F4075PC	IC, CMOS GATE	07263	1
	U14	F4076PC	IC, CMOS TRI-STATE LATCH	07263	1
	U6	F4724PC*	IC, CMOS ADDRESSABLE LATCH	07263	1
	U17,18	MC3440P	IC, GPIB TRANSCEIVER	04713	2
	U15,16	MC3441P	IC, GPIB TRANSCEIVER	04713	2
	U2,3	MM74C42	IC, CMOS BCD-D DECODER	27014	2
	U7-10	MM80C97	IC, CMOS TRI-STATE BUFFER	27014	4
	U21	N82S100N	IC, BIPOLAR FPLA	18324	1
	U11	CD4508BE	IC, CMOS DUAL LATCH	02735	1
	C1,2	CSR13G475KM	CAPACITOR, TANT, 4.7uf,50V	00000	2
	C3-8	CK05BX101M	CAPACITOR, 100pf, 200V	00000	6
	C10-15	CK06BX104M	CAPACITOR, .1uf, 100V	00000	6
	C9	CK06BX103M	CAPACITOR, .01uf, 200V	00000	1
	R35-48	CF 1/4-100	RESISTOR, c/f, 5%	09021	14
	R49	CF 1/4-220	RESISTOR, c/f, 5%	09021	1
	R50	CF 1/4-2200	RESISTOR, c/f, 5%	09021	1
	R33,34	CF 1/4-4700	RESISTOR, c/f, 5%	09021	2
	R25-32	CF 1/4-22K	RESISTOR, c/f, 5%	09021	8
	R1-24	CF 1/4-100K	RESISTOR, c/f, 5%	09021	24
	Q1,2	2N2222	TRANSISTOR	00000	2
	XU1,4,5, 12,13	IEW3700-14B	SOCKET, DIP, 14 PIN	23880	5
	XU2,3,6-10, 14-20	IEW3700-16B	SOCKET, DIP, 16 PIN	23880	14
	XU11	IEQ3700-24B	SOCKET, DIP, 24 PIN	23880	1
	XU21	IEW3700-28B	SOCKET, DIP, 28 PIN	23880	1
	J1	65483-036	HEADER, 2x13	22526	1
	S1-5	1005-692	SWITCH, ROCKER DIP	23880	1
	S7	39-250-RED	SWITCH, PC	81073	1
	S6	MSS-104D-RA	SWITCH, SLIDE	95146	1

*NO SUBSTITUTE

Table 5-12 PWA - Display I/O

FIG	REF DESIG	PART NUMBER	DESCRIPTION	FSCM	QTY
5-8	A1A6	2349-1	PWA, DISPLAY DECODER & MUX		
	(A1A6 DESIGNATOR NOT REPEATED FOR CLARITY)				
		2350-1	PWB	54961	1
		2330-1	CARD EJECTOR	18677	1
		2330-7	CARD EJECTOR (A6)	18677	1
	U9	MC14001CP	IC, CMOS GATE	04713	1
	U11,14	F4011PC	IC, CMOS GATE	07263	2
	U1,12	F4025PC	IC, CMOS GATE	07263	2
	U3,13	F4028PC	IC, CMOS BCD-D DECODER	07263	2
	U10	F4040PC	IC, CMOS CNTR	07263	1
	U7,15	F4063PC	IC, CMOS COMPARITOR	07263	2
	U16,17	F4076PC	IC, CMOS TRI-STATE LATCH	07263	2
	U4	F4081PC	IC, CMOS GATE	07263	1
	U5,6	CD40208BE	IC, CMOS MULTIPORT	02735	2
	U8	MC14558P	IC, CMOS BCD-7SEG.	04713	1
	U2	MM74C42	IC, CMOS BCD-D DECODER	27014	1
	C4	CSR13G475KM	CAPACITOR, TANT,47uf,50V	00000	1
	C2,6-8	CK05BX101M	CAPACITOR, 100pf, 200V	00000	4
	C1	CK05BX471M	CAPACITOR, 470pf, 200V	00000	1
	C3,5,9	CK06BX104M	CAPACITOR, .1uf, 100V	00000	3
	R20-36	CF 1/4-100 5%	RESISTOR, c/f, 100	09021	17
	R40,41	CF 1/4-220 5%	RESISTOR, c/f, 220	09021	2
	R45-52	CF 1/4-4.7K 5%	RESISTOR, c/f, 4.7K	09021	8
	R42	CF 1/4-12K 5%	RESISTOR, c/f, 12K	09021	1
	R44	CF 1/4-22K 5%	RESISTOR, c/f, 22K	09021	1
	R1-19,37, 38,39,43	CF 1/4-100K 5%	RESISTOR, c/f, 100K	09021	23
	Q1,2	2N2222	TRANSISTOR	00000	2
	XU5,6	IEW3700-24B	SOCKET, DIP, 24 PIN	23880	2
	XU1,4,9, 11,12,14	IEW3700-14B	SOCKET, DIP, 14 PIN	23880	6
	XU2,3,7,8, 10,13,15-17	IEW3700-16B	SOCKET, DIP, 16 PIN	23880	9
	J1	65483-036	HEADER, 2x13 PIN	22526	1

Table 5-13 PWA - Power Supply

FIG	REF DESIG	PART NUMBER	DESCRIPTION	FSCM	QTY
5-9	A1A7	2362-1	PWA, POWER SUPPLY		
	(A1A7 DESIGNATORS NOT REPEATED FOR CLARITY)				
		2363-1	PWB	54961	1
	SP1	1C5	POWER SUPPLY, +5V,1.5A	ALPHA POWER	1
	SP2	SP6088	POWER SUPPLY, +8V,-12V	50829	1
	(SP2 SUB.)	920-12-8	POWER SUPPLY, +8V,-12V	28117	
		2330-1	CARD EJECTOR	18677	1
		2330-8	CARD EJECTOR (A7)	18677	1
	TB1	S-172	BARRIER STRIP	71785	1

Table 5-14 PWA - Interconnect Board

FIG	REF DESIG	PART NUMBER	DESCRIPTION	FCSM	QTY
	A1A9	2358-1	PWA, INTERCONNECT BOARD		
		2359-1	PWB	54961	1
	A1A9J1-7	SCC22/D2-2	44 PIN CONNECTOR	23880	7
	A1A9S1	7101A	SWITCH	95146	1
		2008B	SOLDER TERMINAL	83330	3
		2021C	SOLDER TERMINAL	83330	3

Table 5-15 PWA - Display Driver

FIG	REF DESIG	PART NUMBER	DESCRIPTION	FSCM	QTY
5-10	A1A8	2346-1	PWA, DISPLAY		
	(A1A8 DESIGNATOR NOT REPEATED FOR CLARITY)				
		2347-1	PWB	54961	1
	J1	65500-426	CONNECTOR	22526	1
	DS1	BRG9471C	DISPLAY	83594	1
	J2	SRB 2701	CONNECTOR	83594	1
	S1	82-101-71	SWITCH, RANGE	81073	1
	S2	39-1	SWITCH (RED), TEST	81073	1
	S3	39-3	SWITCH (BLK), ZERO	81073	1
	PS1	E705-215UCT	POWER SUPPLY	ENDICOTT	1
	U2	NE584-8 (XC)	IC HI VOLTAGE DRIVER	18324	1
	U1	NE585-S (N)	IC HI VOLTAGE DRIVER	18324	1
	CR1	5082-4684	LED, RED	28480	1
	CR2	5082-4984	LED, GRN	28480	1
	CR3	5082-4584	LED, YEL	28480	1
	R1	CF 1/2-560K 5%	RESISTOR, 560, 1/2W	09021	1
	C2	CSR13G475KM	CAPACITOR, TANT, 4.7uf, 50V	00000	1
	C1	TE-1501	CAPACITOR, TANT, 2uf, 150V	56289	1
		3/16x2-56	SCREW	00000	4

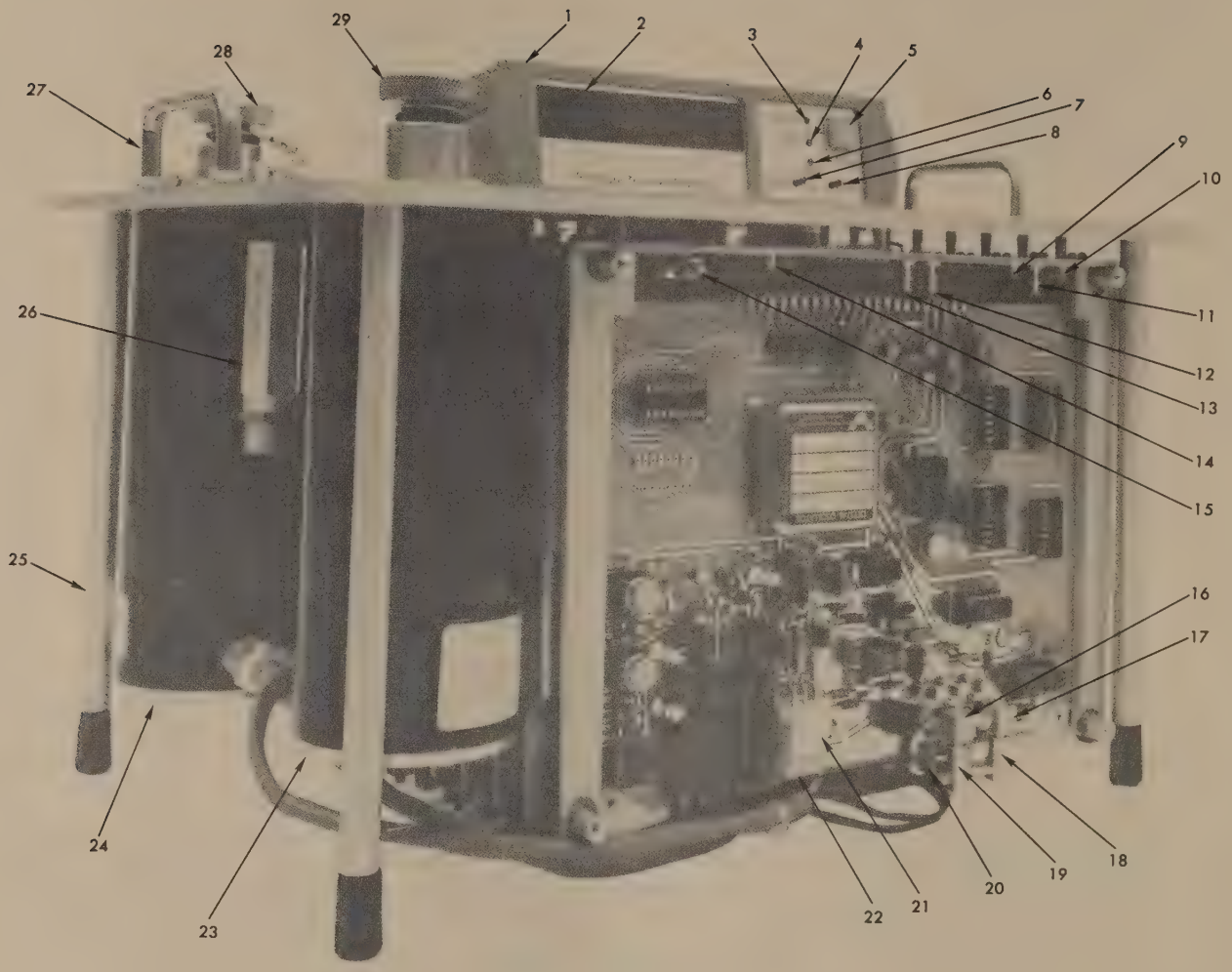


Figure 5-1 Front View of Model PTS-102 with Case Removed

1. Display Assembly
2. Display
3. Indicator Light - Range 1
4. Indicator Light - Range 2
5. Range Select Switch (A9S1)
6. Indicator Light - GPIB
7. Test Switch (A9S2)
8. Zero Switch (A9S3)
9. +8 VDC Test Point
10. -12 VDC Test Point
11. Common Test Point
12. Range 2 Frequency Test Point
13. Range 1 Frequency Test Point
14. +5 VDC Test Point
15. Mode Select Switch (A9S1)
16. Connector (A1J2)
17. Connector (A1J1)
18. Connector (PT1P1)
19. Connector (PT1P2)
20. Common/Ground
21. Connector (A1J3)
22. Connector (PT1P3)
23. Pressure Transducer, Range 1
24. Pressure Transducer, Range 2
25. Service Leg (4)
26. Pressure Relief Valve, Range 2
27. Handle (2)
28. Dust Cap, Range 2
29. Dust Cap, Range 1

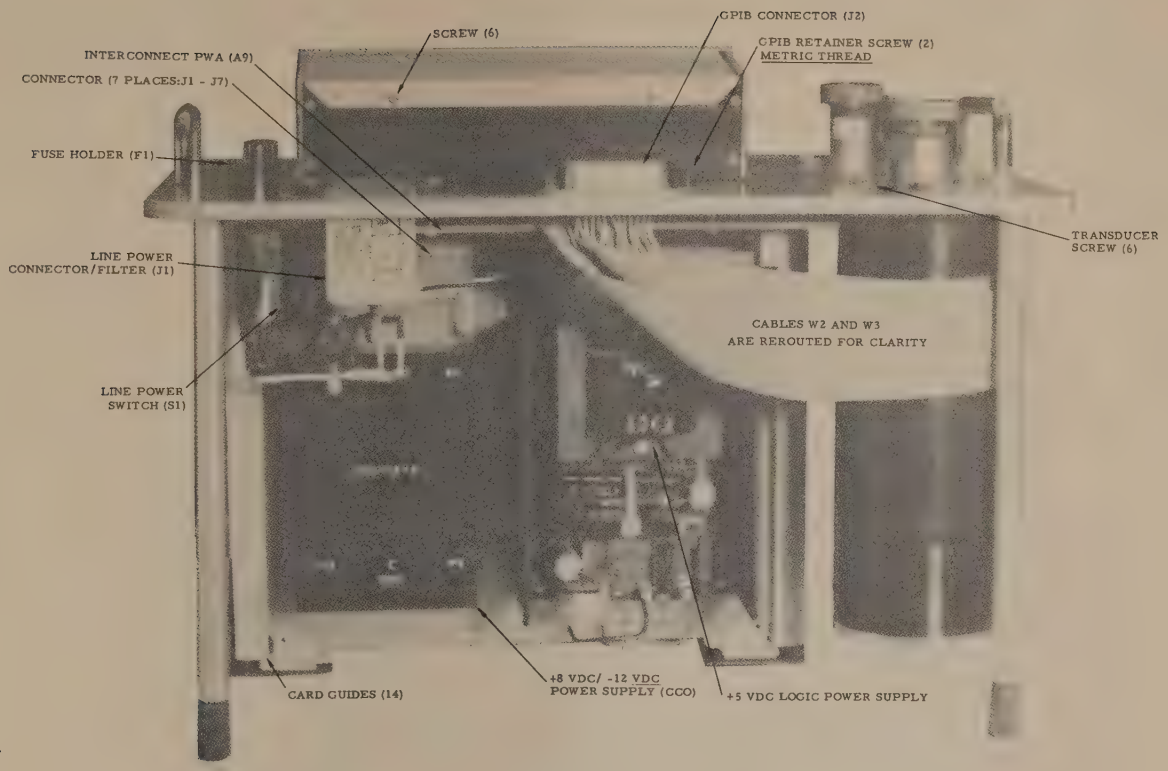


Figure 5-2 Rear View of Model PTS-102

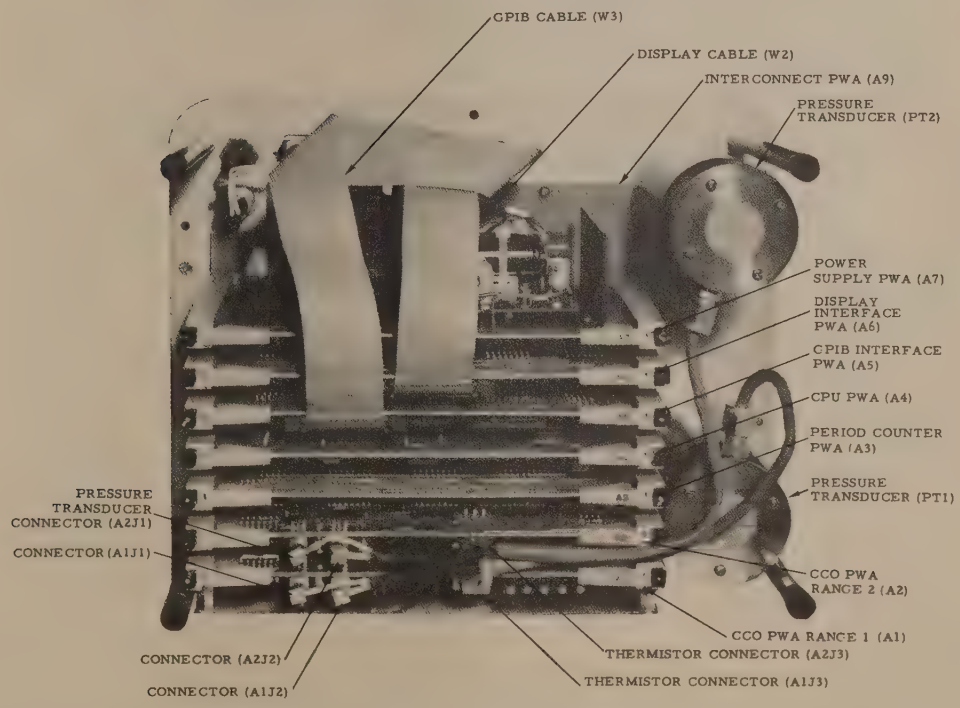


Figure 5-3 Bottom View of Model PTS-102

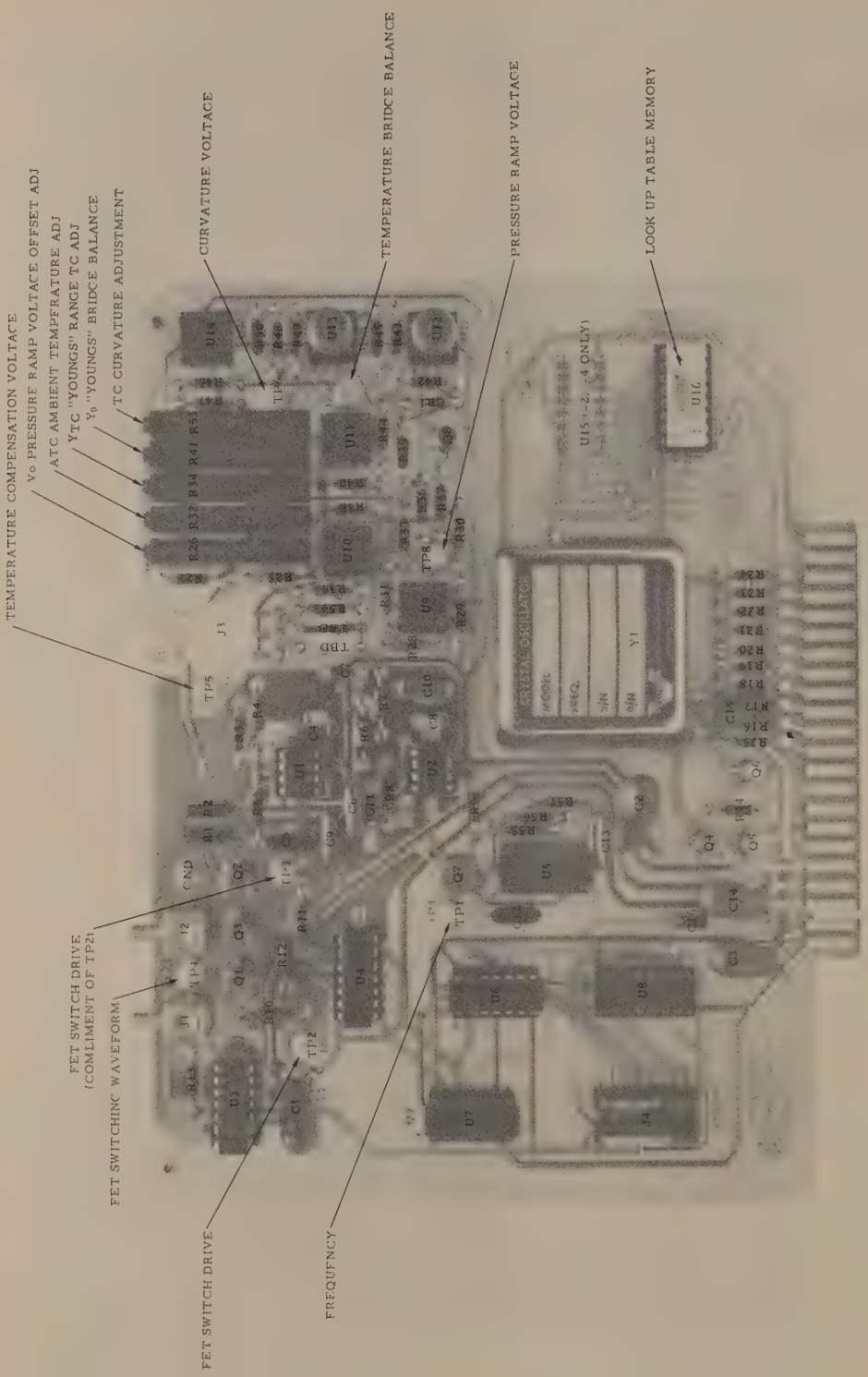


Figure 5-4 PWA, Capacitance Controlled Oscillator (A1,A2)

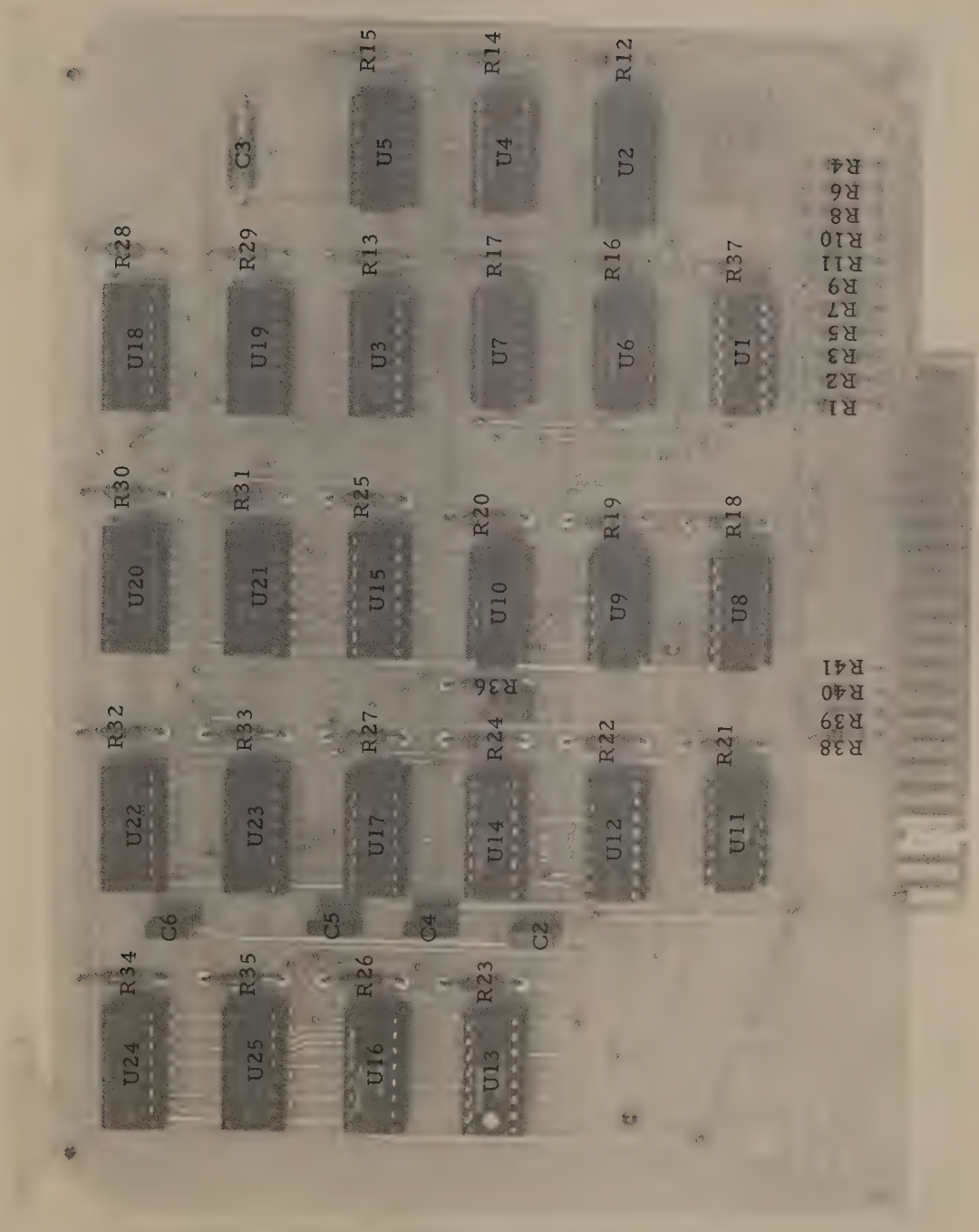


Figure 5-5 PWA, Period Counter (A3)

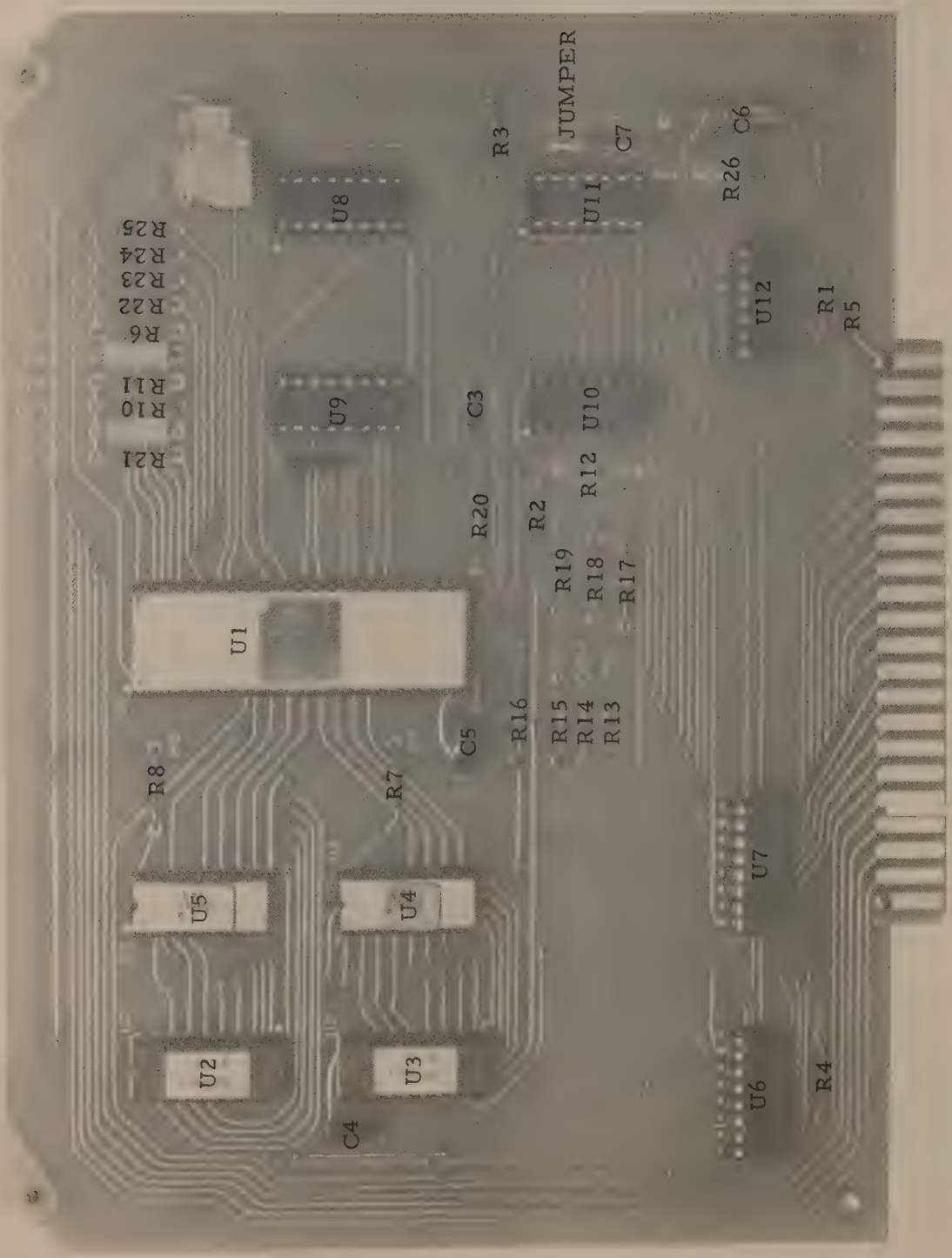


Figure 5-6 PWA, CPU (A4)

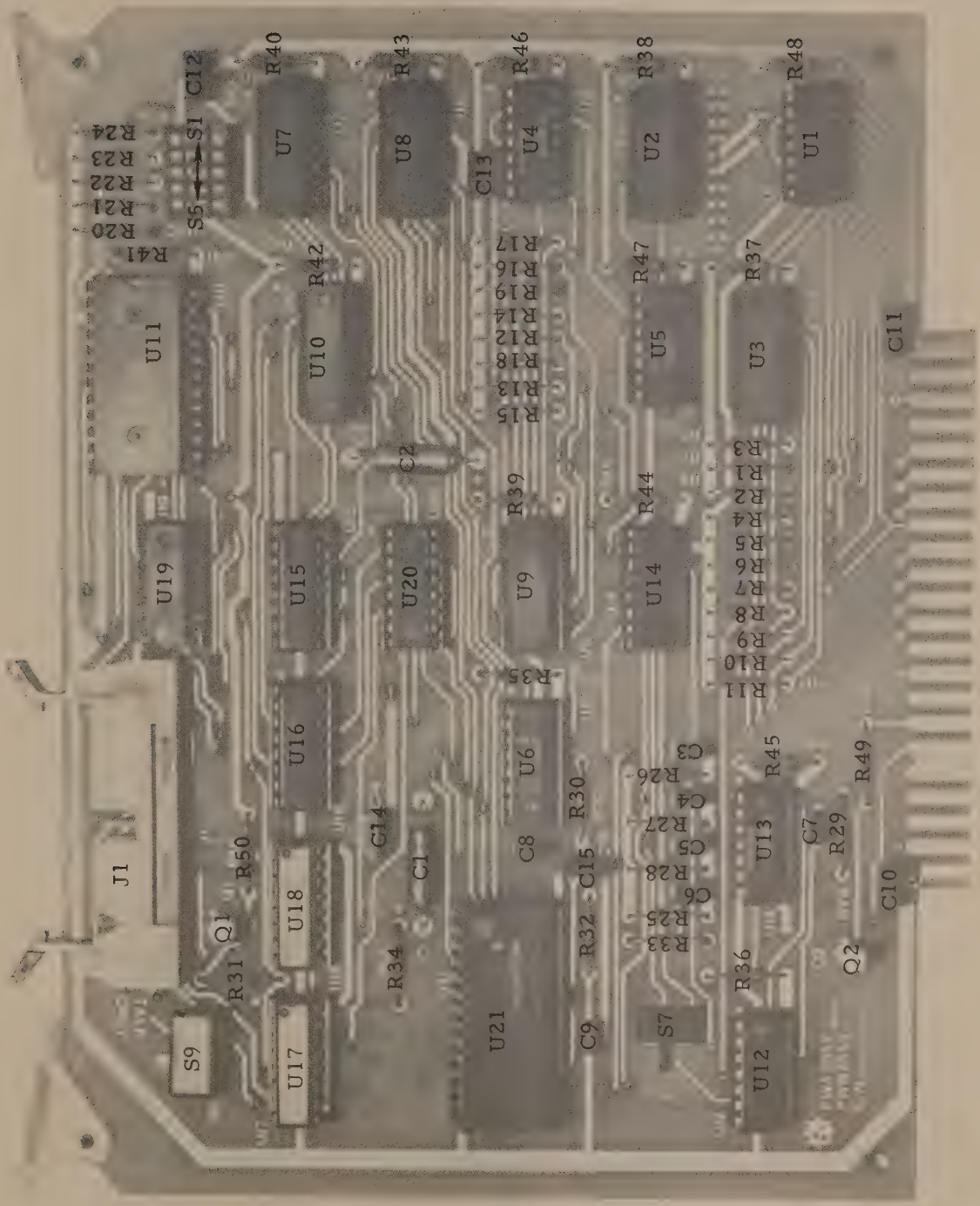


Figure 5-7 PWA, GPIB I/O (A5)

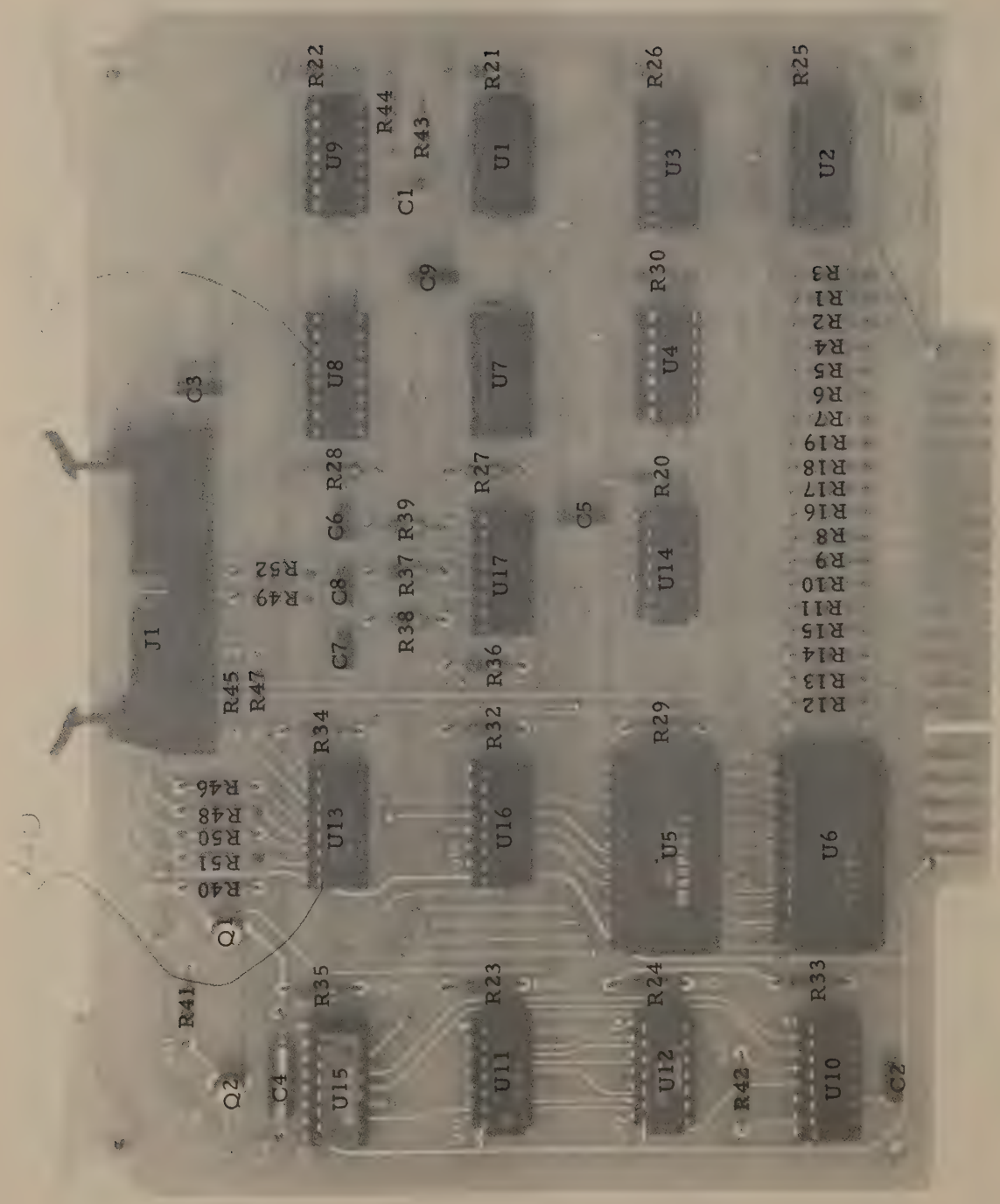
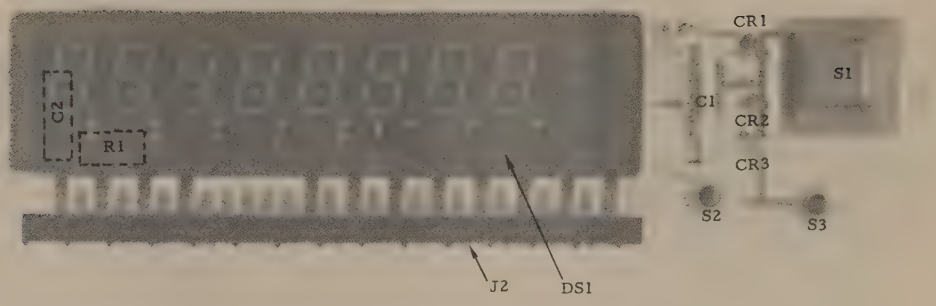


Figure 5-8 PWA, Display I/O (A6)

Figure 5-9 PWA, Power Supply (A7)

FRONT SIDE



BACK SIDE

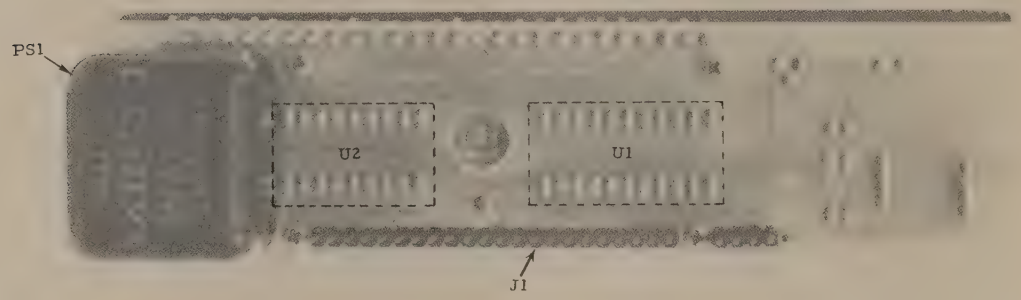


Figure 5-10 PWA, Display Driver (A8)

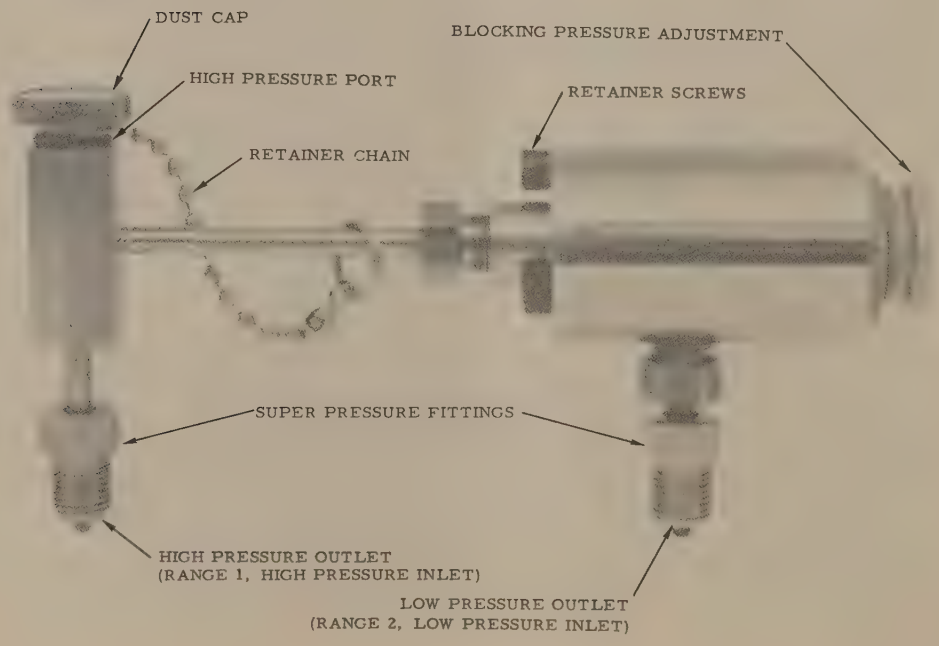


Figure 5-11 Single Port Blocking Valve (Optional Equipment)

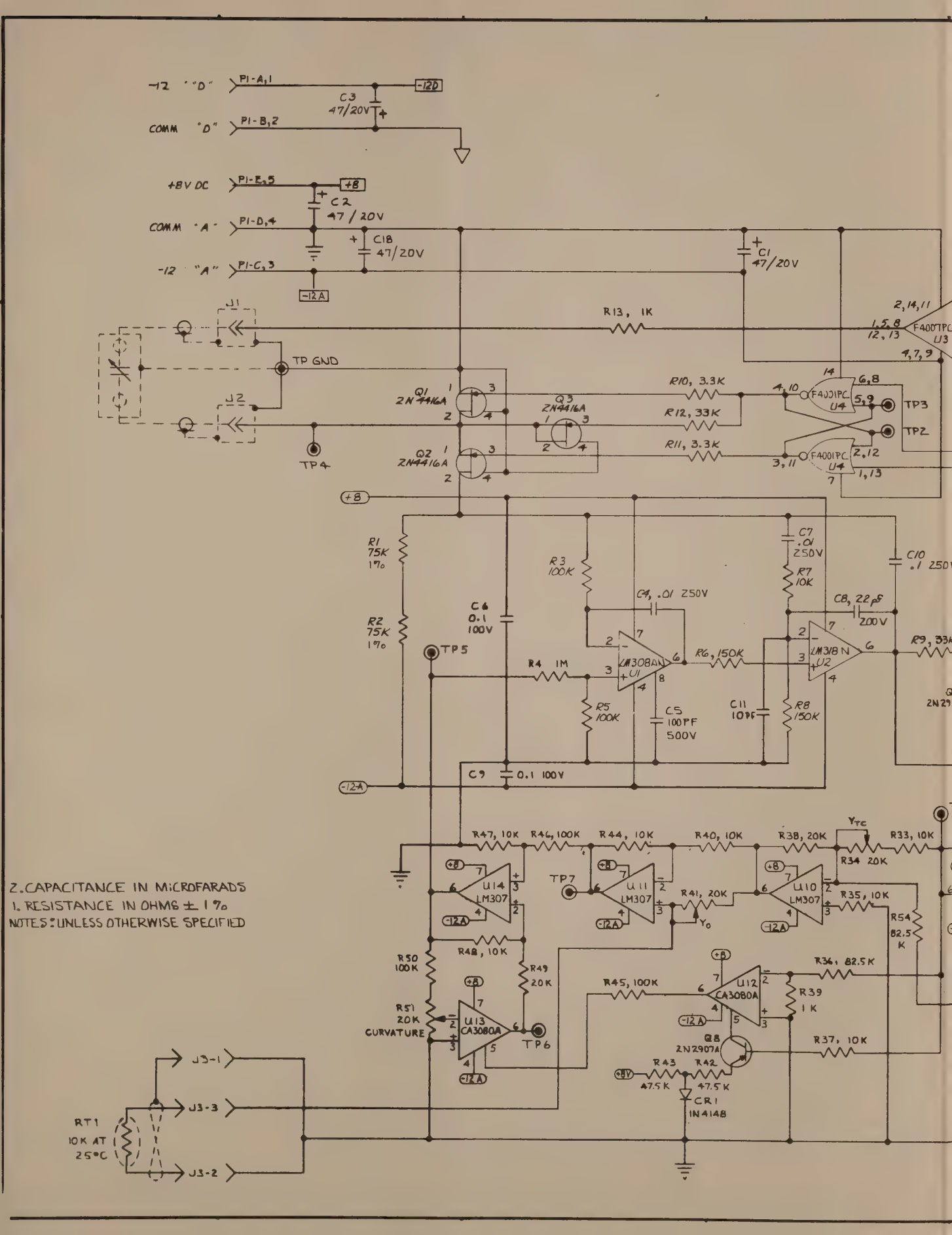
SECTION VI
DOCUMENTATION

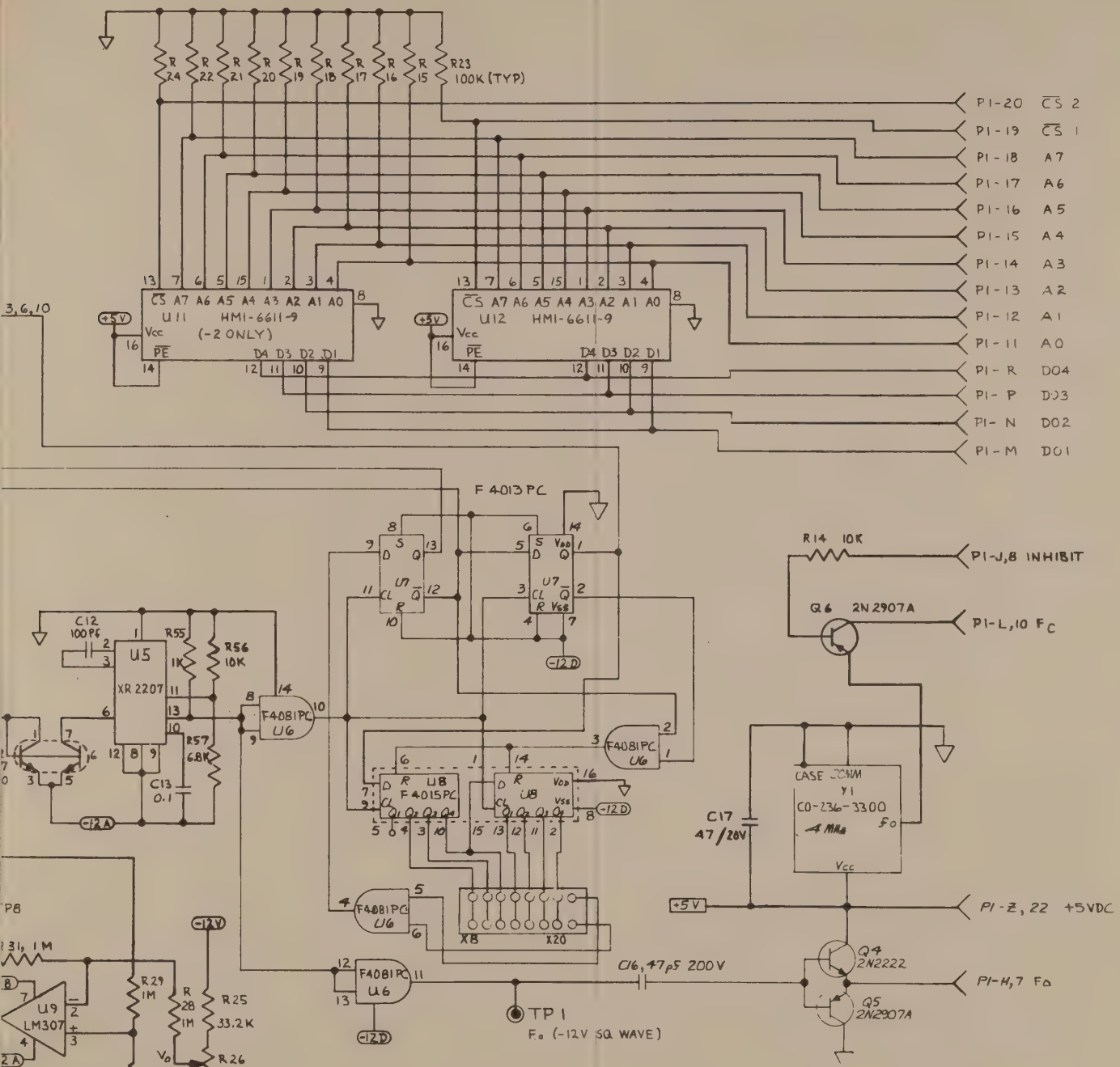
6.1 INTRODUCTION Documentation of the Model PTS-102 includes circuit schematics, program software, firmware memory mapping, and program flowcharts. The intent of this documentation is to aid the repair and calibration technician in maintenance of the Model PTS-102.

6.2 PROPRIETARY DOCUMENTS All documentation in this section is proprietary to Metrology General Corporation. All right to data contained in the following documents are retained by Metrology General Corporation, San Diego, California, and shall not be disclosed or duplicated in whole or in part, or used as the basis for manufacture of apparatus without expressed written permission from Metrology General Corporation.

6.3 LIST OF DOCUMENTS INCLUDED IN THIS SECTION

1. Figure 6-1 CCO Schematic
2. Figure 6-2 Period Counter Schematic
3. Figure 6-3 CPU Schematic
4. Figure 6-4 GPIB Schematic
5. Figure 6-5 Display Decoder/MUX Schematic
6. Figure 6-6 Power Supply Schematic
7. Figure 6-7 Display Driver Schematic
8. Figure 6-8 System Interconnect Schematic
9. Figure 6-9 System Flow Chart
10. Table 6-1 Memory Mapped Program & I/O
11. Table 6-2 Microprocessor Program


-12 "D"
P1-A,1
-12D
C3 47/20V
COMM "D"
P1-B,2
+8V DC
P1-E,5
+8
C2 47/20V
COMM "A"
P1-D,4
C18 47/20V
-12 "A"
P1-C,3
-12A
C1 47/20V
J1
J2
TP GND
TP4
R13, 1K
Q1 2N4416A
Q2 2N4416A
Q3 2N4416A
R10, 3.3K
R12, 33K
R11, 3.3K
F4001PC U4
TP3
TP2
+8
R1 75K 1%
R2 75K 1%
C6 0.1 100V
TP5
R3 100K
C4, .01 Z50V
R4 1M
R5 100K
LM308AN U1
R6, 150K
C5 100PF 500V
C7 .01 Z50V
R7 10K
C8, 22pF 200V
C10 .1 Z50V
LM318N U2
C11 100pF
R8 150K
R9, 33K
C9 0.1 100V
-12A
R47, 10K
R46, 100K
R44, 10K
R40, 10K
R38, 20K
R33, 10K
R34 20K
TP7
R41, 20K
R35, 10K
R54 82.5K
U14 LM307
U11 LM307
U10 LM307
R48, 10K
R50 100K
R49 20K
R51 20K CURVATURE
U13 CA3080A
TP6
R45, 100K
U12 CA3080A
R39 1K
R36, 82.5K
R37, 10K
Q8 2N2907A
R43 47.5K
R42 47.5K
CR1 IN4148
J3-1
J3-3
J3-2
RT1 10K AT 25°C
2. CAPACITANCE IN MICROFARADS
1. RESISTANCE IN OHMS ± 1%
NOTES: UNLESS OTHERWISE SPECIFIED



PROPRIETARY DOCUMENT

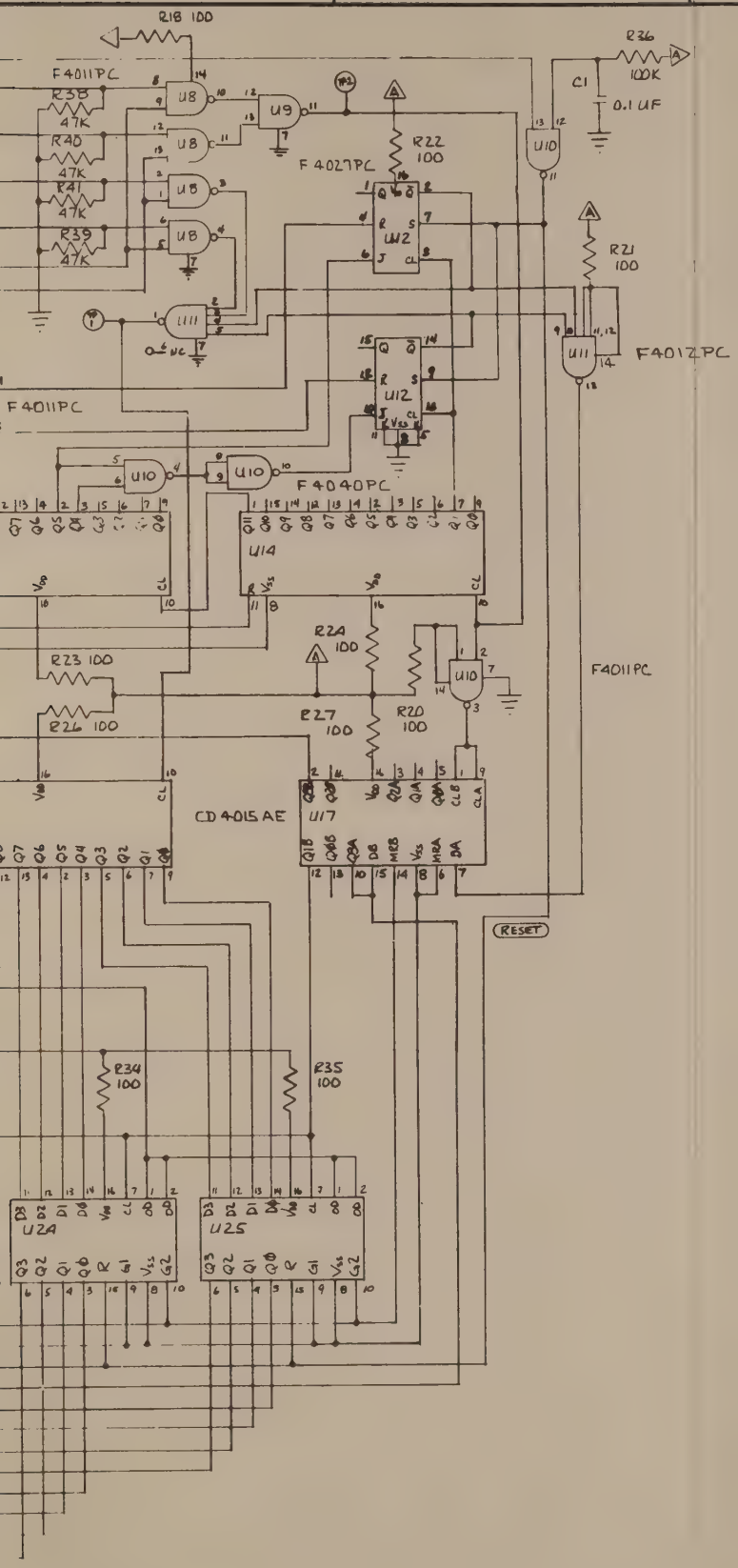
All rights to data contained in this document are retained by

METROLOGY GENERAL CORP.

San Diego, CA., and shall not be disclosed or duplicated in whole or in part, or used as the basis for manufacture of apparatus without expressed written permission.

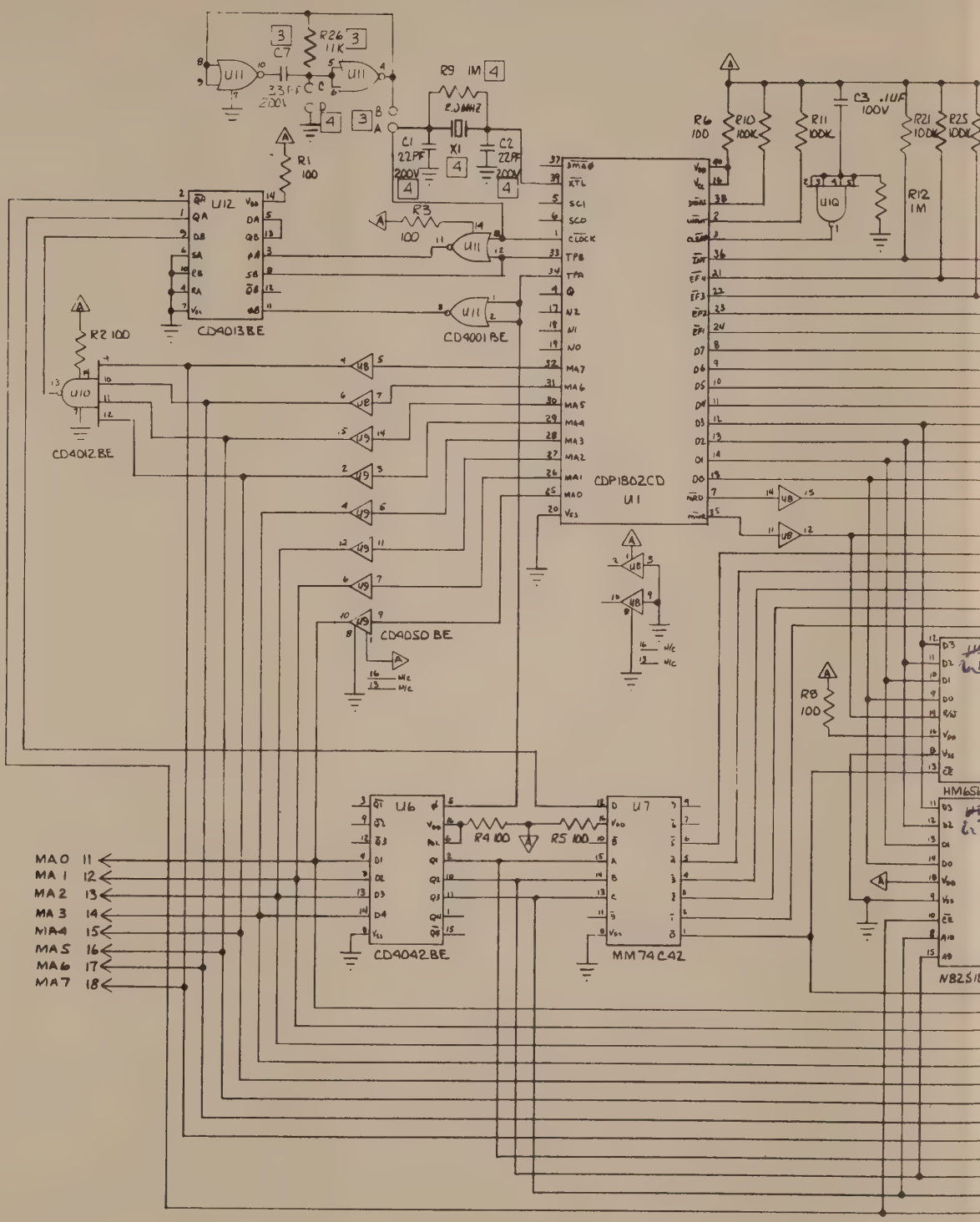
Figure 6-1 CCO Schematic

ALL RESISTANCE VALUES IN OHMS, 1/4 WATT ±5% AND CAPACITANCE IN MFD ±10% UNLESS OTHERWISE SPECIFIED.



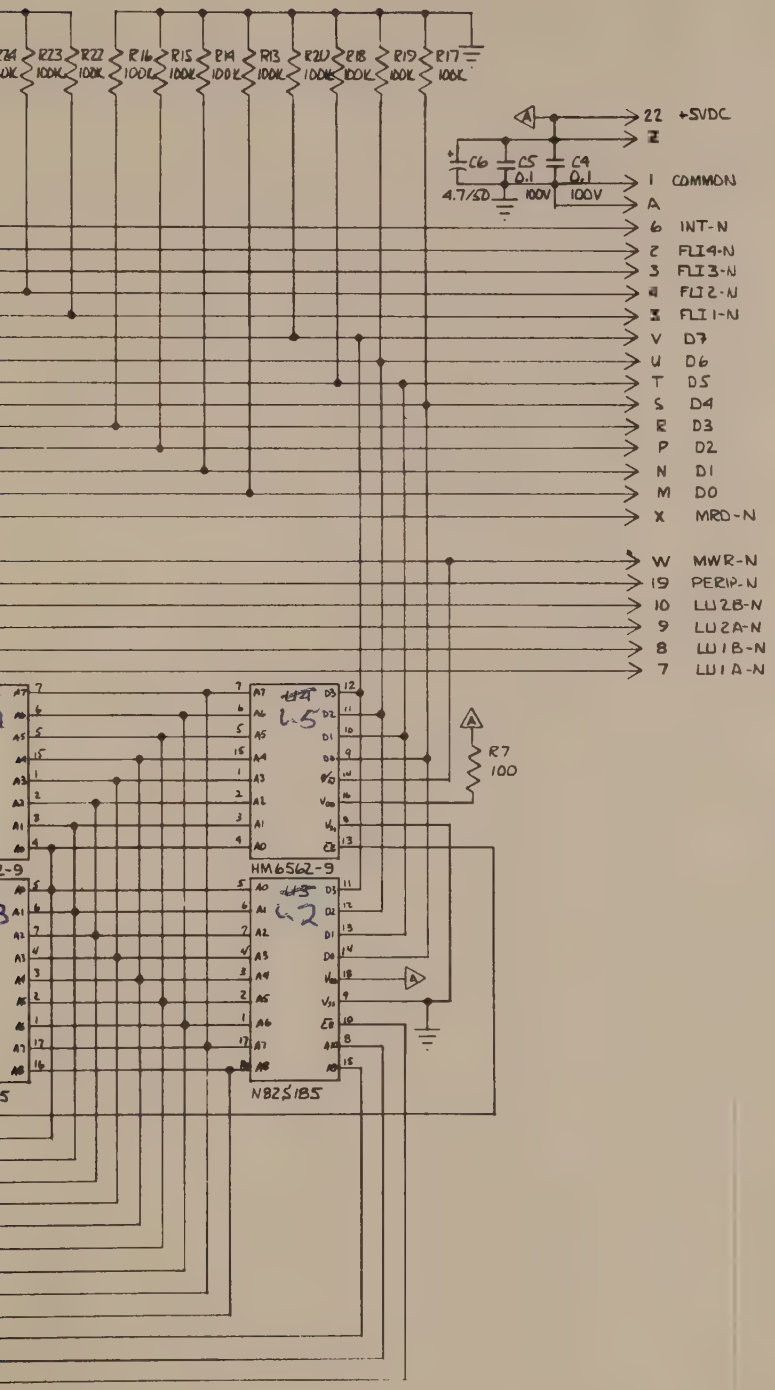
PROPRIETARY DOCUMENT
All rights to data contained in this document are retained by
METROLOGY GENERAL CORP.
San Diego, CA., and shall not be disclosed or duplicated in whole or in part, or used as the basis for manufacture of apparatus without expressed written permission.

Figure 6-2 Period Counter Schematic



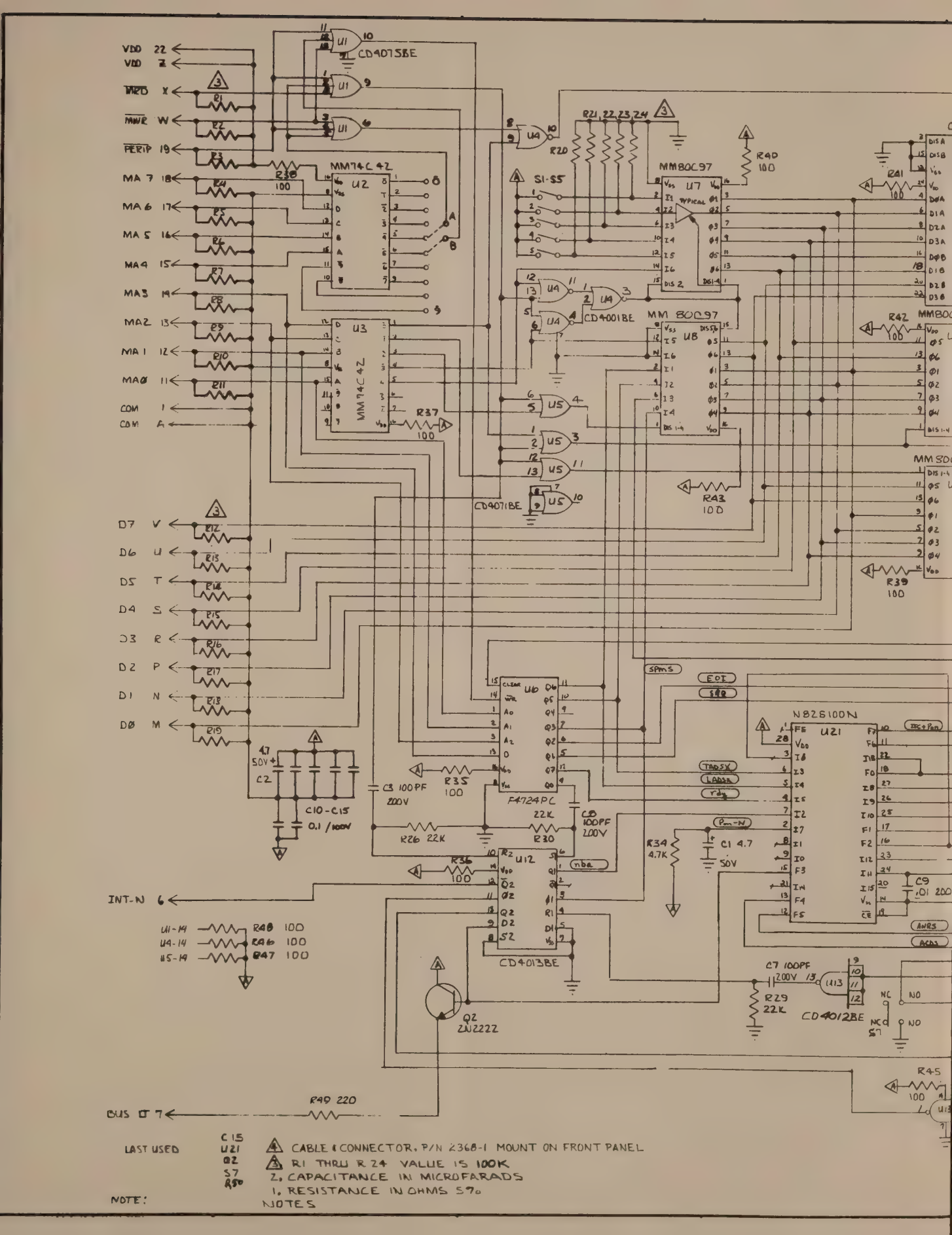
LAST USED: U12
R26
C7
X1

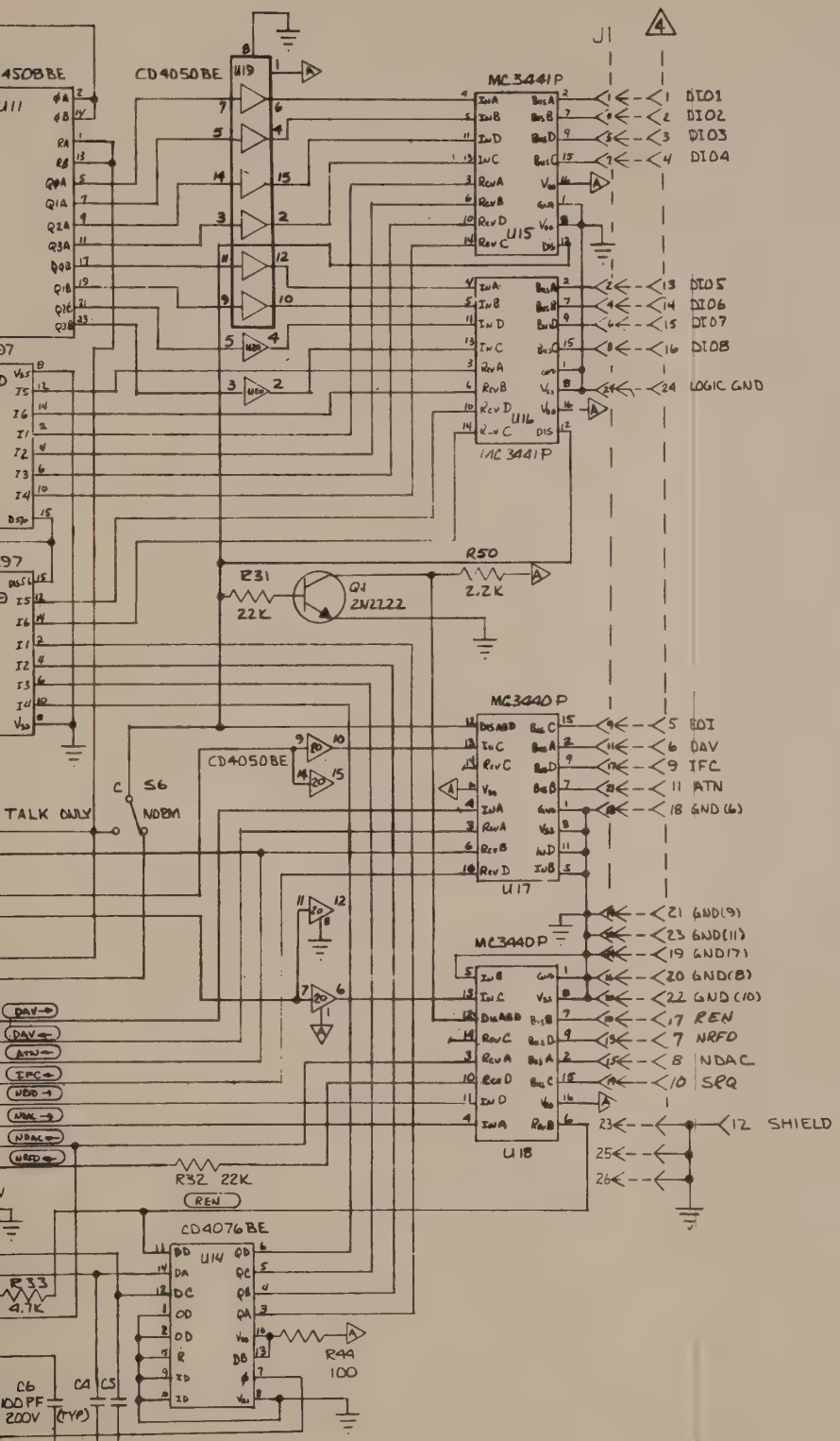
4 INSTALL JUMPER C-D, C1, C2, R9 & X1 FOR -1 ASSY
3. INSTALL JUMPER A-B, R26 & C7 FOR -2 ASSY
2 CAPACITANCE IN MICROFARADS.
1 RESISTANCE IN OHMS ±5%., ¼ WATT
NOTES: UNLESS OTHERWISE NOTED



PROPRIETARY DOCUMENT
All rights to data contained in this document are retained by
METROLOGY GENERAL CORP.
San Diego, CA., and shall not be disclosed or duplicated in whole or in part, or used as the basis for manufacture of apparatus without expressed written permission.

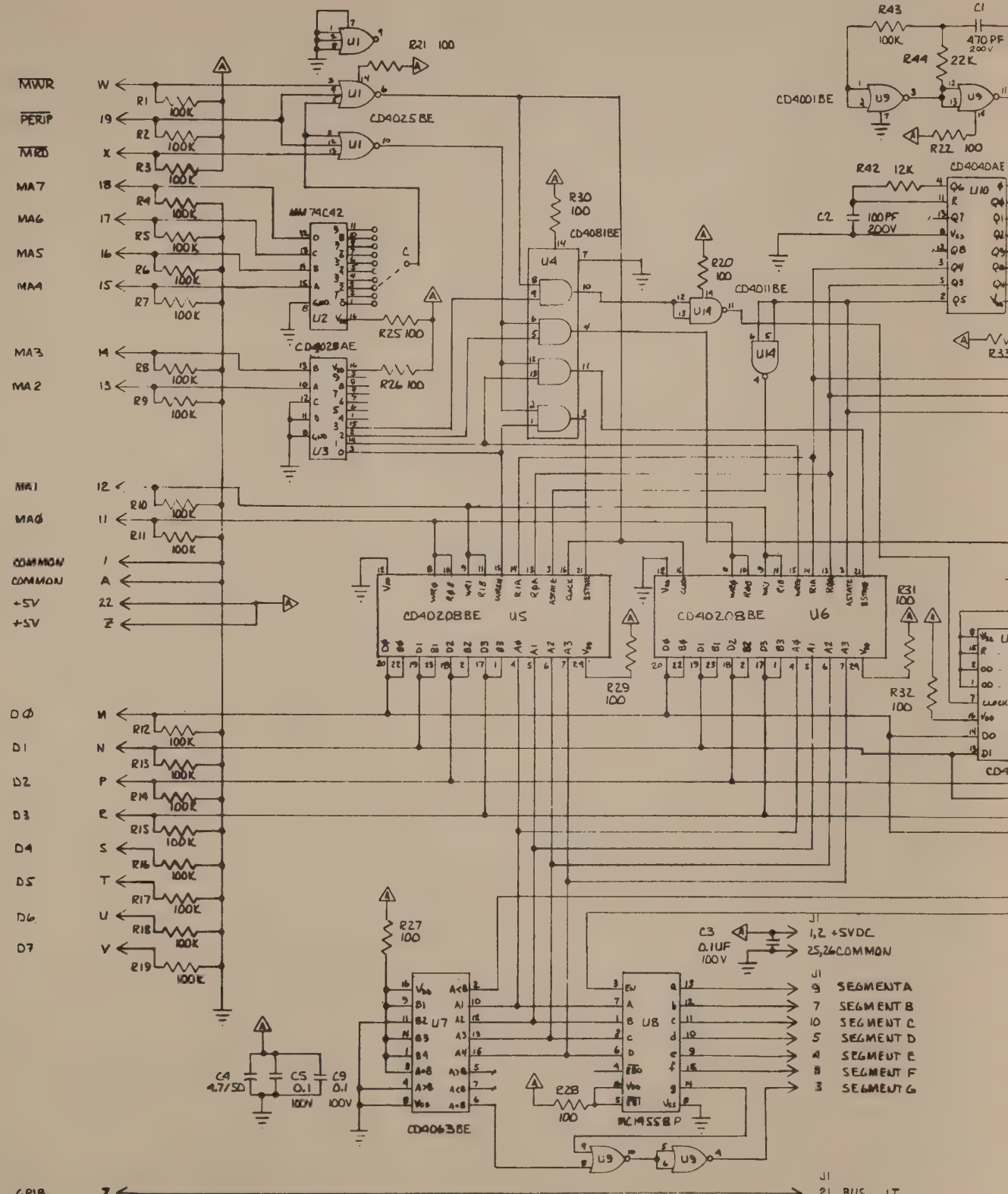
Figure 6-3 CPU Schematic


VDD 22
VDD 2
RD X
MWR W
PERIP 19
MA 7 18
MA 6 17
MA 5 16
MA4 15
MA3 14
MA2 13
MA1 12
MA0 11
COM 1
COM A
D7 V
D6 U
D5 T
D4 S
D3 R
D2 P
D1 N
D0 M
INT-N 6
BUS D 7
U1 CD4075BE
MM74C42
U2
U3
R30 100
R37 100
CD4071BE
CD4001BE
MM80C97
U7
U8
R20
R21, 22, 23, 24
R40 100
R41 100
R42 100
R43 100
R39 100
SI-S5
R1 R2 R3 R4 R5 R6 R7 R8 R9 R10 R11 R12 R13 R14 R15 R16 R17 R18 R19
C2 47 50V
C10-C15 0.1 /100V
C3 100PF 200V
R35 100
F4724PC
U6
C8 100PF 200V
R26 22K
R30
U12
R36 100
CD4013BE
U1-14 R48 100
U4-14 R46 100
U5-14 R47 100
R49 220
Q2 2N2222
5PMS
EOI
SRQ
N82S100N
U21
TADSX
LADSX
R/W
Pm-W
C1 4.7 50V
R34 4.7K
C9 .01 200
AMRS
ACRS
C7 100PF 200V
U13
R29 22K
CD4012BE
NC NO
NC NO
S7
R45 100
LAST USED C15 U21 Q2 S7 R50
NOTE:
4 CABLE & CONNECTOR, P/N 2368-1 MOUNT ON FRONT PANEL
3 R1 THRU R 24 VALUE IS 100K
2, CAPACITANCE IN MICROFARADS
1, RESISTANCE IN OHMS 5%
NOTES



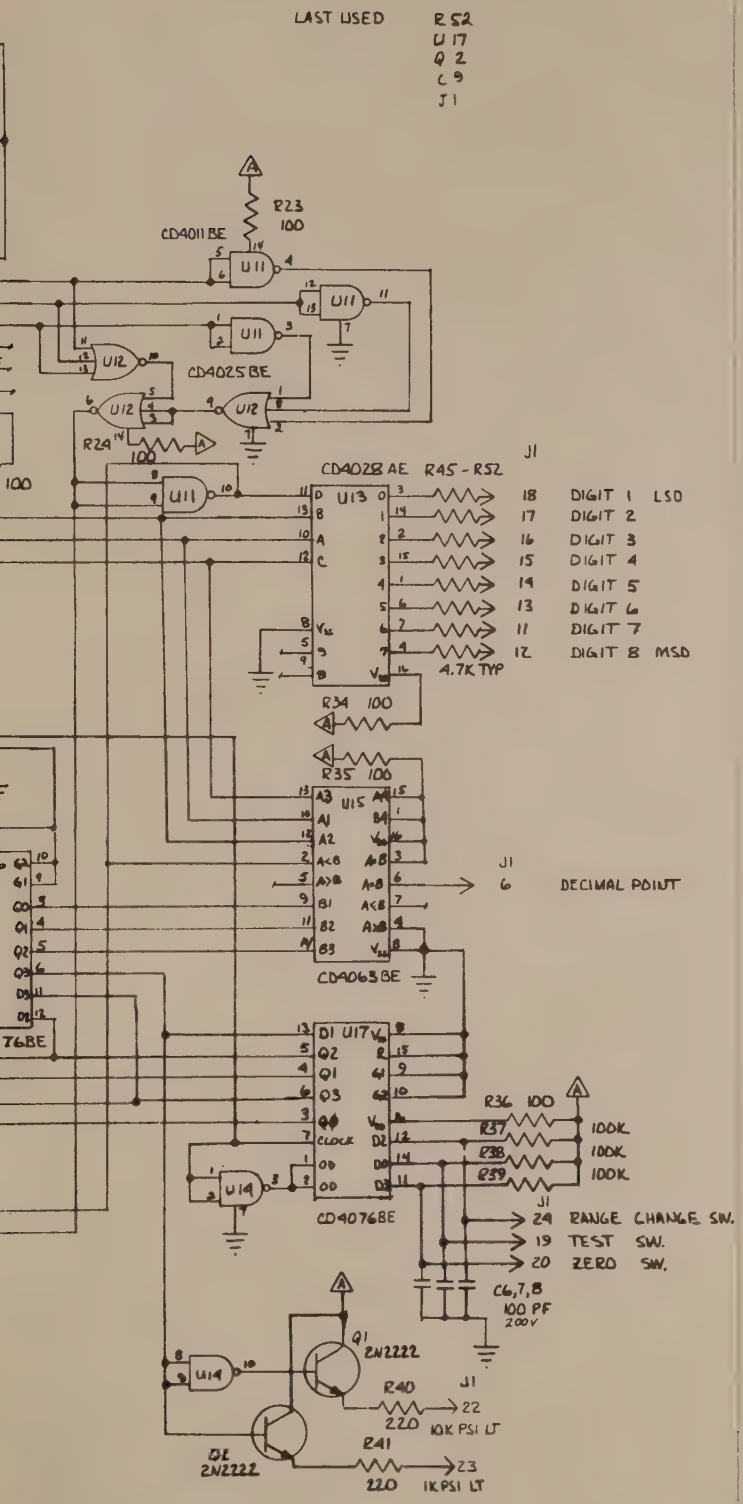
PROPRIETARY DOCUMENT
All rights to data contained in this document are retained by
METROLOGY GENERAL CORP.
San Diego, CA., and shall not be disclosed or duplicated in whole or in part, or used as the basis for manufacture of apparatus without expressed written permission.

Figure 6-4 GPIB Schematic



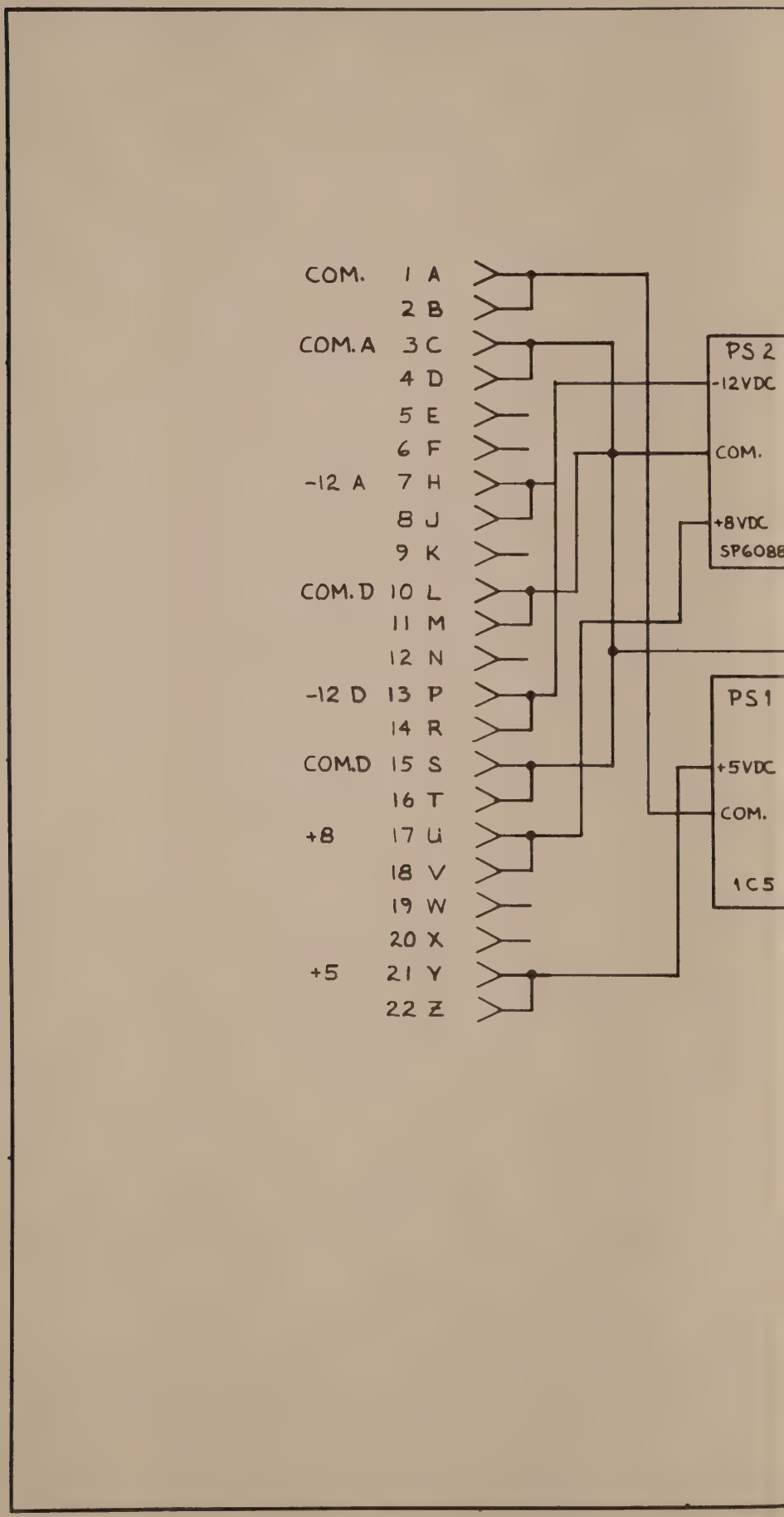
NOTES:

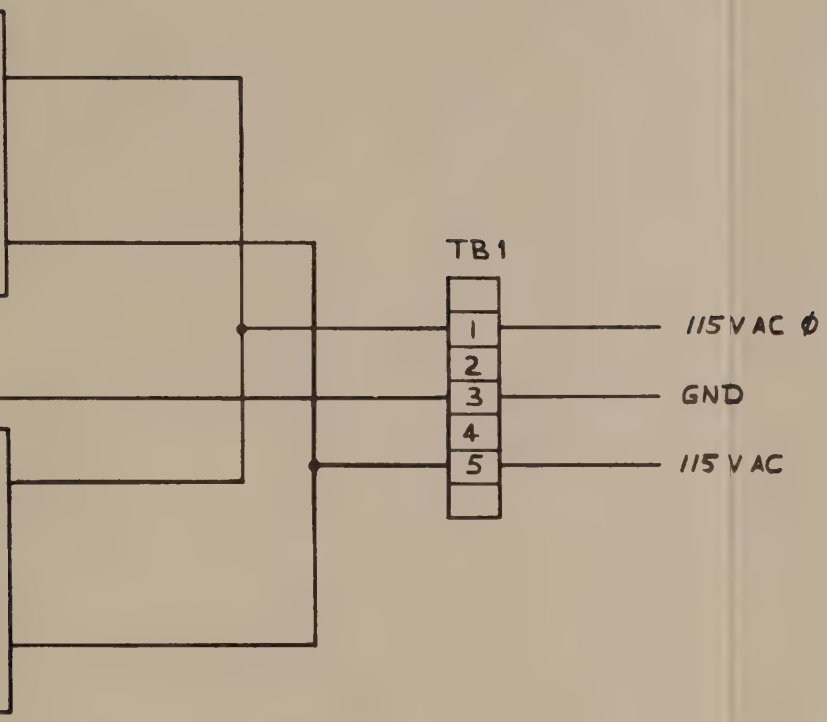
1. RESISTORS IN OHMS 5%
2. CAPACITANCE IN MICROFARADS



PROPRIETARY DOCUMENT
All rights to data contained in this document are retained by
METROLOGY GENERAL CORP.
San Diego, CA., and shall not be disclosed or duplicated in whole or in part, or used as the basis for manufacture of apparatus without expressed written permission.

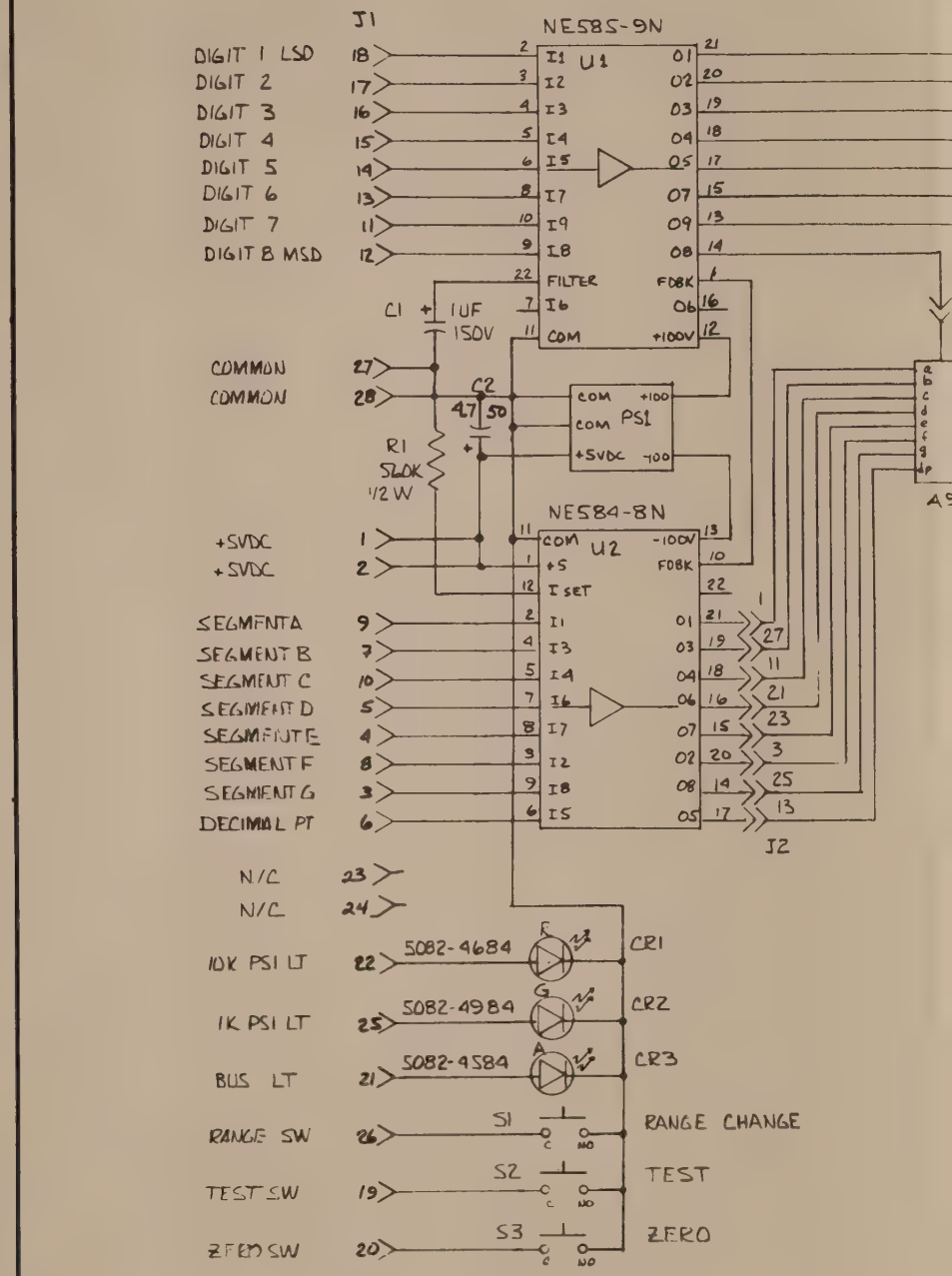
Figure 6-5 Display Decoder/MUX Schematic


COM.
1 A
2 B
COM. A
3 C
4 D
5 E
6 F
-12 A
7 H
8 J
9 K
COM. D
10 L
11 M
12 N
-12 D
13 P
14 R
COM.D
15 S
16 T
+8
17 U
18 V
19 W
20 X
+5
21 Y
22 Z
PS 2
-12VDC
COM.
+8VDC
SP6088
PS 1
+5VDC
COM.
1C5

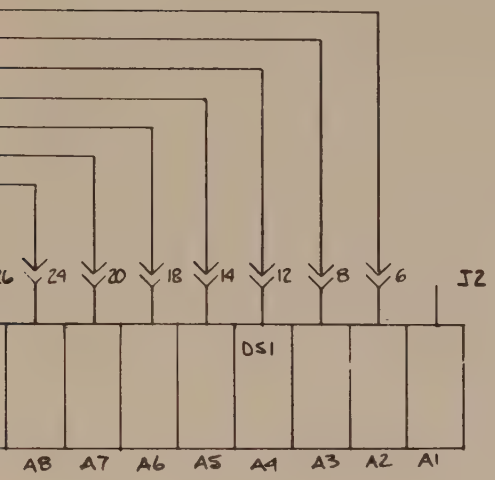


PROPRIETARY DOCUMENT
All rights to data contained in this document are retained by
METROLOGY GENERAL CORP.
San Diego, CA., and shall not be disclosed or duplicated in whole or in part, or used as the basis for manufacture of apparatus without expressed written permission.

Figure 6-6 Power Supply Schematic

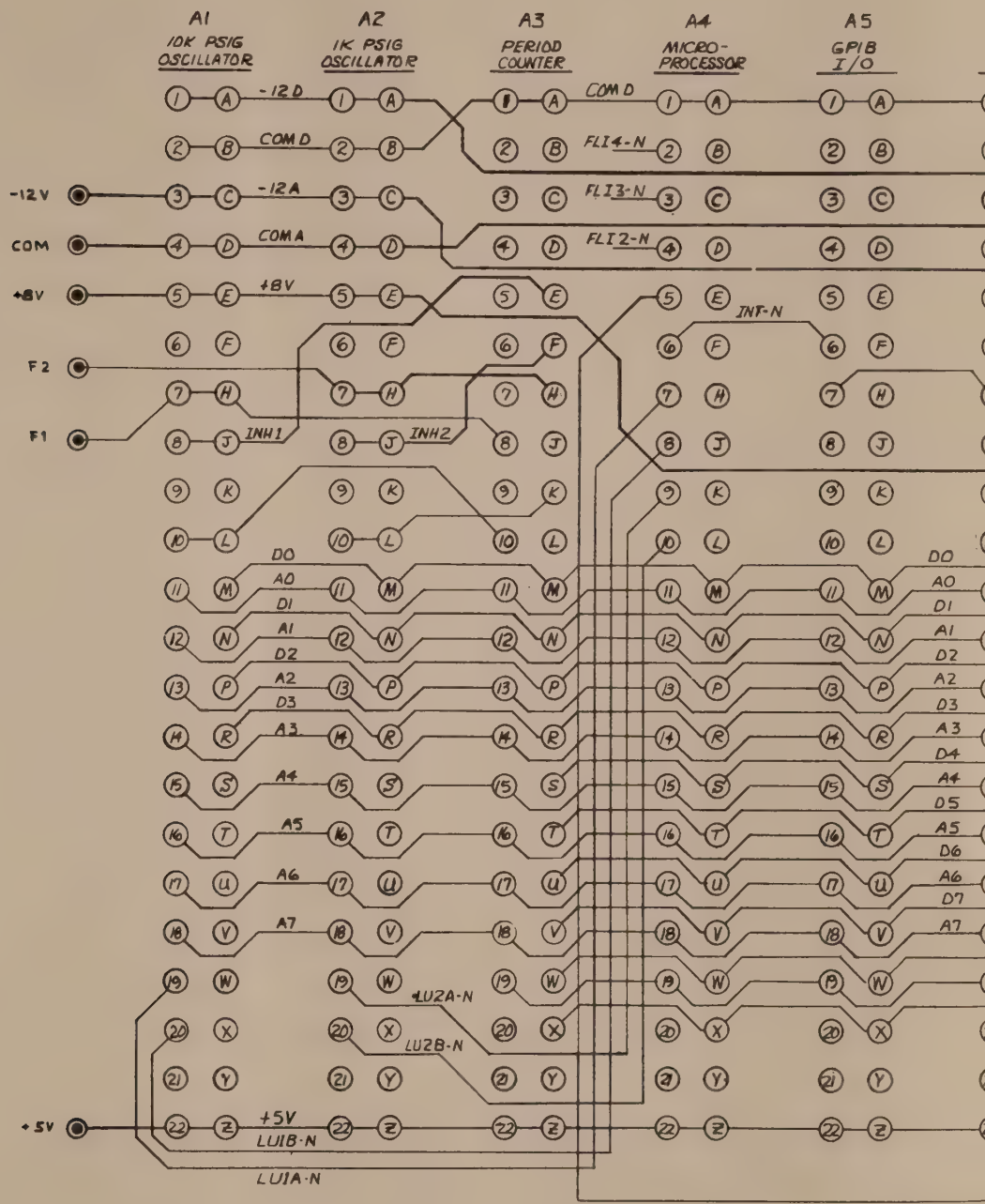


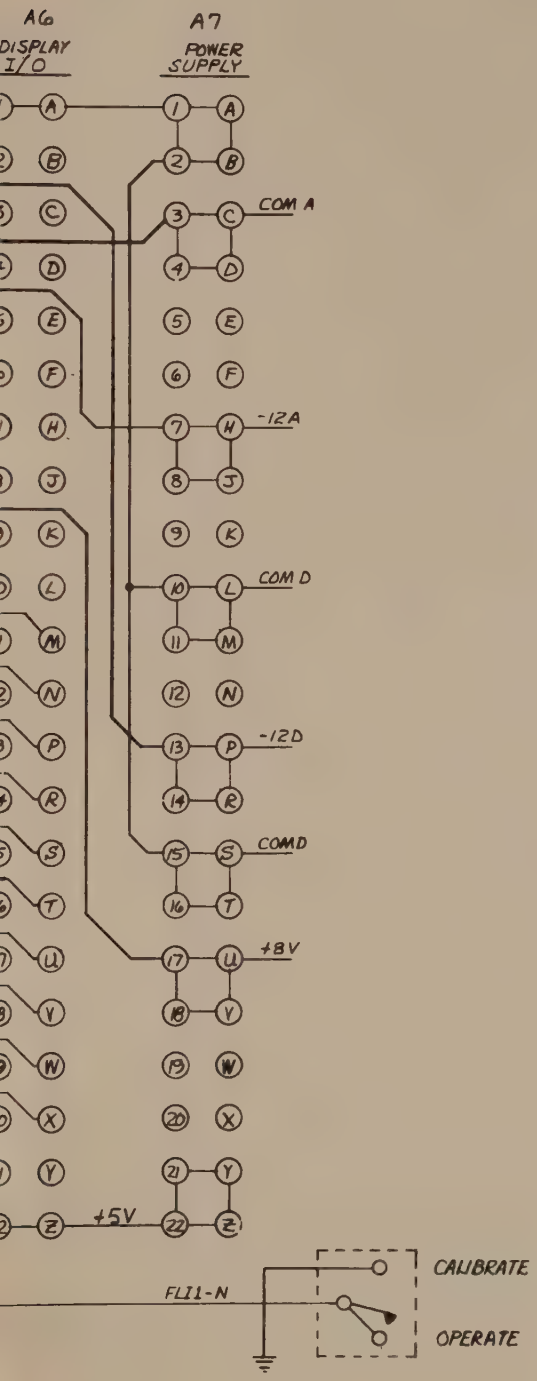
LAST USED U2
DS1
PS1
CR3
S3
R1
C2



PROPRIETARY DOCUMENT
All rights to data contained in this document
are retained by
METROLOGY GENERAL CORP.
San Diego, CA., and shall not be disclosed or
duplicated in whole or in part, or used as the
basis for manufacture of apparatus without
expressed written permission.

Figure 6-7 Display Driver Schematic


A1
10K PSIG OSCILLATOR
A2
1K PSIG OSCILLATOR
A3
PERIOD COUNTER
A4
MICRO-PROCESSOR
A5
GPIB I/O
-12V
COM
+8V
F2
F1
+5V
-12D
COM D
-12A
COM A
+8V
INH1
INH2
COM D
FLI4-N
FLI3-N
FLI2-N
INT-N
D0
A0
D1
A1
D2
A2
D3
A3
A4
A5
A6
A7
D4
D5
D6
D7
LU2A-N
LU2B-N
+5V
LU1B-N
LU1A-N



PROPRIETARY DOCUMENT
All rights to data contained in this document are retained by
METROLOGY GENERAL CORP.
San Diego, CA., and shall not be disclosed or duplicated in whole or in part, or used as the basis for manufacture of apparatus without expressed written permission.

Figure 6-8 System Interconnect Schematic

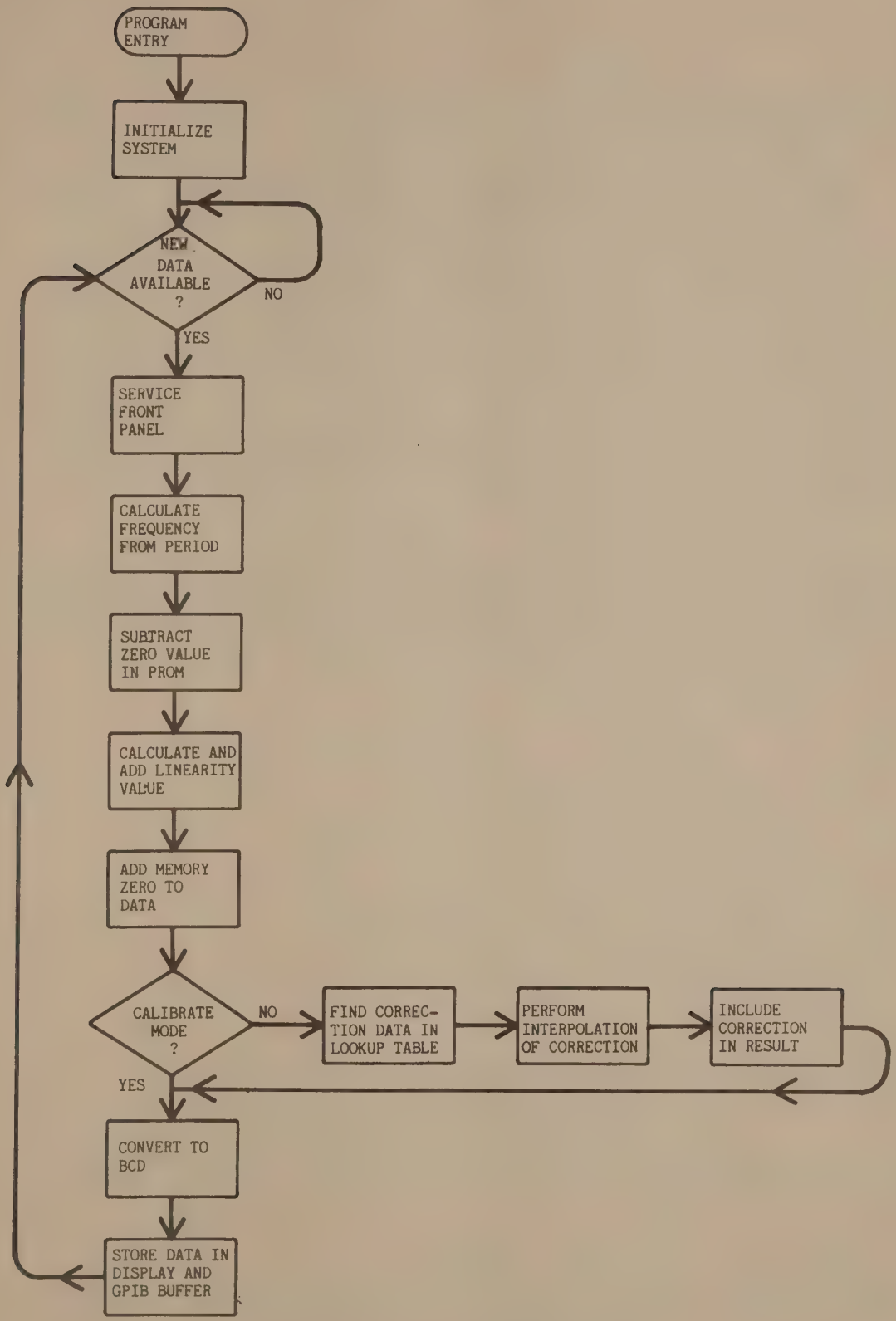


Figure 6-9 System Flow Chart

Table 6-1 Memory Map of Program and I/O

HEXIDECIMAL ADDRESS	FUNCTION
FD70 - FD7D	PERIPHERAL, DISPLAY DECODER/MUX I/O
FD40 - FD5F	PERIPHERAL, GPIB I/O
FD20 - FD2F	PERIPHERAL, PERIOD COUNTER
FC00 - FCFF	LUT, PROM A2 (EXPANSION)
FB00 - FBFF	LUT, PROM A2
FA00 - FAFF	LUT, PROM A1 (EXPANSION)
F900 - F9FF	LUT, PROM A1
F880 - F8FF	STACK
0156 - 07FD	SUB-ROUTINES
0000 - 0155	MAIN LINE PROGRAM RUNNING LOOP

Table 6-2 Microprocessor Program

```
0000 $                  0001 ..PEGISTEP DEFINITIONS
0000 $                  0002 IV=1
0000 $                  0003 SP=2
0000 $                  0004 PC=3
0000 $                  0005 JSP=4
0000 $                  0006 RTN=5
0000 $                  0007 LKR=6
0000 $                  0008 ERR=7
0000 $                  0009 PAR=8
0000 $                  0010 JUBC=9
0000 $                  0011 NBR=10
0000 $                  0012 CTR=11
0000 $                  0013 MAR=12
0000 $                  0014 DAR=13
0000 $                  0015 TMP=14
0000 $                  0016 SCR=15
0000 $                  0017 ..CONSTANTS
0000 $                  0018 CR=#0D
0000 $                  0019 LF=#0A
0000 $                  0020 ELNG=#24
0000 $                  0021 DLY=#60
0000 $                  0022 ..ADDRESS CONSTANTS
0000 $                  0023 LE=#24  ..COUNTER ADDRESSES (PERIP)+ #24 ETC.
0000 $                  0024 NLE=#25
0000 $                  0025 RTEN=#26
0000 $                  0026 FONE=#27
0000 $                  0027 CSTAT=#20
0000 $                  0028 DPREG=#E0 ..STACK ADDRESSES (STACK) + #E0 ETC.
0000 $                  0029 RSLT=#DA
0000 $                  0030 SWSTAT=#E4
0000 $                  0031 BUFF2=#CD
0000 $                  0032 TESTAT=#E2
0000 $                  0033 BUFF1=#FC
0000 $                  0034 DESTAT=#E8
0000 $                  0035 STACK=#F800 ..UPPER ADDRESS CONSTANTS.
0000 $                  0036 PERIP=#FD00
0000 $                  0037 PROM1=#F900
0000 $                  0038 PROM2=#FB00
0000 $                  0039 ..TUBECUTING ADDRESS CONSTANTS
0000 $                  0040 DECBE=#01DE
0000 $                  0041 MLESSD=#027F
0000 $                  0042 MPLUSD=#01FF
0000 $                  0043 LIMP=#2F5
0000 $                  0044 COMP=#07AE
0000 $                  0045 CALL=#03D0
0000 $                  0046 RETPGM=#03E0
0000 $                  0047 PANEL=#03EC
0000 $                  0048 ERROR=#04FF
0000 $                  0049 B2DEC=#0585
0000 $                  0050 RATIO=#04A4
0000 $                  0051 IBIRV=#07E0
0000 $                  0052 ..

0000 $                  0053 ..INITIALIZATION OF THE SYSTEM
0000 $                  0054 ..
0000 71$                0055          DIS ..DISABLES INTERRUPTS;SETS SP AND PC =0
0001 00$                0056          ;#00 ..AND GETS THE STARTING ADDRESS INTO PC.
0002 F800$              0057          LDI A.1(START)
0004 B3$                0058          PHI PC
0005 F80A$              0059          LDI A.0(START-3)
0007 A3$                0060          PLO PC
0008 71$                0061          DIS ..NOW SET PC=3;SP=2.
0009 23$                0062          ;#23
000A F8FF$              0063          LDI #FF
000C A8$                0064          LMP
000D F8EF$              0065 START:   LDI #BF
000F A2$                0066          PLO SP
0010 F807$              0067          LDI A.1(IBIRV) ..SET UP INTERRUPT SERVICE
0012 B1$                0068          PHI IV ;.VECTOR.
0013 F8E0$              0069          LDI A.0(IBIRV)
0015 A1$                0070          PLO IV
0016 F803$              0071          LDI A.1(CALL) ..AND CALL ADDRESS,
0018 B4$                0072          PHI JSP

0019 F8D0$              0073          LDI A.0(CALL)
001B A4$                0074          PLO JSP
001C F803$              0075          LDI A.1(RETPGM) ..AND RETURN ADDRESS,
001E B5$                0076          PHI RTN
001F F8E0$              0077          LDI A.0(RETPGM)
0021 A5$                0078          PLO RTN
0022 F804$              0079          LDI A.1(ERROR) ..AND ERROR ADDRESS,
0024 B7$                0080          PHI ERR
0025 F866$              0081          LDI A.0(ERROR)
0027 A7$                0082          PLO ERR
0028 F8FD$              0083          LDI A.1(PERIP) ..AND PERIP UPPER ADDRESS,
002A B8$                0084          PHI PAR
002B F8F8$              0085          LDI A.1(STACK) ..AND STACK ADDRESS
002D B2$                0086          PHI SP
002E F800$              0087 STLP:    LDI #00 ..CLEAR STACK TO ZEROS.
0030 73$                0088          STXD
0031 82$                0089          GLO SP
0032 3A2E$              0090          BNZ STLP
0034 52$                0091          STR SP ..STORE LAST ZERO.
0035 F82F$              0092          LDI RTEN
0037 A8$                0093          PLO PAR ..SET RANGE TO 10K PSI.
0038 08$                0094          STP PAR
0039 3066$              0095          BR INITLP ..AND BEGIN PROGRAM.

003B $                  0096 ..ROUTINE IS THE MAINLINE PROGRAM RUNNING LOOP.
003B $                  0097 ..ENTRY SHOULD BE TO INITLP.
003B $                  0098 ..ROUTINE USES SUBROUTINE CALLS OF THE SCRT TYPE.
003B 0000000080180000$  0099 CONST$ ,0,0,0,0,#80,#18,#00,#0A,#28
0042 0A28$              0099
0044 00FFFB000000BC$    0100          ,0,#FF,#FB,0,0,0,#BC,,#93,#32,0,0,0
004B 93320000000$       0100
0050 00093D0C000C$      0101          ,#00,#09,#3D,#0C,#00,#0C ..
0056 $                  0102          ..CONSTANTS IN CONST ARE: 0,FS FREQ. X 64(LSB
0056 $                  0103          ..FIRST),262400,262400,0,LINEARITY CONSTANT,
0056 $                  0104          ..0,4000000 AND 131074 X 6.
0056 F825$              0105 RCOUN2$  LDI NLE
0058 A8$                0106          PLO PAR
005A 08$                0107           TP PAR ..SET LATCH NOT ENABLED.
005A 2A$                0108 RCOUN3$  DEC NBR ..PART OF THE TIME LOOP.
005B 8A$                0109          GLO NBR
005C 3A69$              0110          BNZ RCOUN1 ..THROUGH THE LOOP AGAIN.
005E D4$                0111          SEP JSP
005F 03EC$              0112          ,A(PANEL) ..ALLOWS ACCESS TO PANEL IN CASE.
0061 9A$                0113          GHI NBR
0062 3A69$              0114          BNZ RCOUN1
0064 D7$                0115          SEP ERR ..ERROR IF TOO LONG.
0065 24$                0116          ,ELNG ..DISPLAY ERROR CODE "9"
0066 F860$              0117 INITLP$  LDI DLY ..DELAY CONSTANT.
0068 BA$                0118          PHI NBR
0069 F8F8$              0119 RCOUN1$   LDI A.1(STACK) ..LOAD STACK POINTER.
006B $                  0120
006B B2$                0121          PHI SP
006C BC$                0122          PHI MAR
006D F881$              0123          LDI #81
006F A2$                0124          PLO SP
0070 F820$              0125          LDI CSTAT
0072 A8$                0126          PLO PAR
0073 08$                0127          LDN PAR ..READ COUNTER STATUS.
0074 73$                0128          STXD ..SAVE ON THE STACK.
0075 F6$                0129          SHR
0076 3356$              0130          BDF RCOUN2 ..IF LATCH IS ENABLED ITS WRONG.
0078 FE$                0131          SHL
0079 FE$                0132          SHL
007A 3B5A$              0133          BNF RCOUN3 ..DATA NOT READY LOOP
007C F824$              0134 RCOUN4$  LDI LE
007E A8$                0135          PLO PAR
007F 58$                0136          STP PAR ..WRITE LATCH ENABLE.
0080 D4$                0137          SEP JSR ..DATA READY, BUT FIRST SERVICE
0081 03EC$              0138          ,A(PANEL) ..THE PANEL SWITCHES.
0083 F820$              0139          LDI CSTAT
0085 A8$                0140          PLO PAR
0086 08$                0141          LDN PAR ..READ STATUS.
0087 FE$                0142          SHL
0088 337C$              0143          BDF RCOUN4 ..LOOP UNTIL READY CLEAR.
008A 93$                0144          GHI PC
008B BE$                0145          PHI TMP
008C F83B$              0146          LDI A.0(CONST) ..ADDRESS OF CONSTANT TABLE.
008E AE$                0147          PLO TMP
008F F815$              0148          LDI 21
0091 AF$                0149          PLO SCR
```

```
0092 4E$          0150 STCON$: LDA TMP ..STORE 21 BYTES OF CONSTANTS ON STACK
0093 73$          0151         STXD ..BEFORE PROCEEDING.
0094 2F$          0152         DEC SCR
0095 8F$          0153         GLO SCR
0096 3A92$        0154         BNZ STCONS
0098 18$          0155         INC PAP
0099 48$          0156         LDA PAP ..READ THREE DATA BYTES AND STORE
009A 73$          0157         STXD ..ON THE STACK.
009B 48$          0158         LDA PAP
009C 73$          0159         STXD
009D 48$          0160         LDA PAP
009E 73$          0161         STXD
009F 18$          0162         INC PAP
00A0 58$          0163         STR PAP ..SETS LATCH NOT ENABLED WHEN DONE.
00A1 F806$        0164         LDI 6
00A3 AF$          0165         PLO SCR
00A4 4E$          0166 PCOUN5: LDA TMP
00A5 73$          0167         STXD ..CONTINUE TO PUT CONSTANTS ON STACK.
00A6 2F$          0168         DEC SCR
00A7 8F$          0169         GLO SCR
00A8 3AA4$        0170         BNZ PCOUN5
00AA D4$          0171         SEP JSR
00AB 04A4$        0172         ,A(RATIO) ..CONVERTS TO FREQUENCY X 5.
00AD 2D$          0173         DEC DAP ..POINTER TO LSB OF DATA.
00AE F880$        0174         LDI A.0(STACK)
00B0 AC$          0175         PLO MAP ..POINTS TO STORAGE LOCATION.
00B1 F803$        0176         LDI 3
00B3 AF$          0177         PLO SCR ..LOOP COUNTER.
00B4 0D$          0178 MVDAT:  LDN DAP ..LOOP MOVES DATA TO TWO LOCATIONS.
00B5 73$          0179         STXD
00B6 5C$          0180         STR MAP
00B7 2C$          0181         DEC MAP
00B8 2D$          0182         DEC DAP
00B9 2F$          0183         DEC SCR
00BA 8F$          0184         GLO SCR
00BB 3AB4$        0185         BNZ MVDAT
00BD D4$          0186         SEP JSR ..CALCULATES DATA LESS FULL SCALE.
00BE 0275$        0187         ,A(MLESSD)
00C0 F881$        0188         LDI #81
00C2 AC$          0189         PLO MAP ..RECOVERY OF STATUS.
00C3 F8EA$        0190         LDI DREG
00C5 AD$          0191         PLO DAP
00C6 0C$          0192         LDN MAP
00C7 FA04$        0193         ANI #04 ..TEST THE 10K RANGE.
00C9 32D4$        0194         BZ PCOUN1 ..IF NOT ON IT IS 1K RANGE.
00CB F801$        0195         LDI #01 ..DECIMAL SETTING
00CD 5D$          0196         STR DAP
00CE FE$          0197         SHL
00CF 4A$          0198         PLO SUBC
00D0 F8F9$        0199         LDI A.1(PROM1)
00D2 30DA$        0200         BR PC1
00D4 F80A$        0201 PCOUN1: LDI #0A
00D6 5D$          0202         STR DAP
00D7 A9$          0203         PLO SUBC
00D8 F8FB$        0204         LDI A.1(PROM2) ..LOOK UP TABLE ADDRESS.
00DA B9$          0205 PC1:    PHI SUBC ..STORE PROM ADDRESS FOR LATER..
00DB BC$          0206         PHI MAP ..LOOK UP ZERO NOW.
00DC F808$        0207         LDI 8
00DE AC$          0208         PLO MAP
00DF D4$          0209         SEP JSR
00E0 01D6$        0210         ,A(DEC2B) ..CONVERT THE ZERO TO BINARY.
00E2 07$          0211         ,#07 ..THE DATA IS SEVEN DIGITS LONG.
00E3 92$          0212         GHI SP
00E4 BC$          0213         PHI MAP
00E5 82$          0214         GLO SP
00E6 FC03$        0215         ADI 3
00E8 AC$          0216         PLO MAP
00E9 AE$          0217         PLO TMP
00EA F880$        0218         LDI A.0(STACK)
00EC AD$          0219         PLO DAP
00ED D4$          0220         SEP JSR
00EE 0275$        0221         ,A(MLESSD) ..SUBTRACT THE ZERO VALUE
00F0 8E$          0222         GLO TMP ..TWO TIMES.
00F1 AC$          0223         PLO MAP
00F2 FC06$        0224         ADI 6
00F4 AD$          0225         PLO DAP
00F5 D4$          0226         SEP JSR
00F6 0275$        0227         ,A(MLESSD)
00F8 8E$          0228         GLO TMP
00F9 A2$          0229         PLO SP
00FA D4$          0230         SEP JSR
00FB 04A9$        0231         ,A(RATIO) ..PERFORM SECOND ORDER LINEARITY.
00FD D4$          0232         SEP JSR
00FE 04A9$        0233         ,A(RATIO) ..MULTIPLY RESULT BY .1  (256/2560)
0100 82$          0234         GLO SP
0101 FC03$        0235         ADI 3
0103 AC$          0236         PLO MAP
0104 AE$          0237         PLO TMP ..TEMPORARILY SAVE IT.
0105 FC03$        0238         ADI 3
0107 AD$          0239         PLO DAP
0108 D4$          0240         SEP JSR
0109 0288$        0241         ,A(MPLUSD)
010B 8E$          0242         GLO TMP
010C A2$          0243         PLO SP
010D 89$          0244         GLO SUBC
010E AC$          0245         PLO MAP ..POINT TO LSBYTE.
010F F8E4$        0246         LDI SWSTAT
0111 AD$          0247         PLO DAP
0112 0D$          0248         LDN DAP ..GET SWITCH REGISTER.
0113 FA08$        0249         ANI 8
0115 322F$        0250         BZ ZERA ..IF ZERO SWITCH IS NOT PUSHED.
0117 0D$          0251         LDN DAP
0118 FAF0$        0252         ANI #F0
011A 5D$          0253         STR DAP ..CLEAR THE SWITCH REGISTER.
011B F880$        0254         LDI A.0(STACK)
011D AD$          0255         PLO DAP
011E F803$        0256         LDI 3
0120 AB$          0257         PLO CTR
0121 F6$          0258         SHR ..GUARANTEE NO BORROW.
0122 EC$          0259         SEX MAP
0123 0D$          0260 BRPT1:  LDN DAP ..GETS DATA, 2'S COMPLIMENT AND
0124 7D00$        0261         SDBI #00 ..STORES IN ZERO REGISTER.
0126 2D$          0262         DEC DAP
0127 73$          0263         STXD
0128 2B$          0264         DEC CTR
0129 8B$          0265         GLO CTR
012A 3A23$        0266         BNZ BRPT1
012C 89$          0267         GLO SUBC
012D AC$          0268         PLO MAP
012E E2$          0269         SEX SP
012F F880$        0270 ZERA:   LDI A.0(STACK)
0131 AD$          0271         PLO DAP
0132 D4$          0272         SEP JSR
0133 0288$        0273         ,A(MPLUSD) ..ADD ZERO IN.
0135 344C$        0274         B1 CALI ..IF CALIBRATE SWITCH IS PUSHED.
0137 99$          0275         GHI SUBC ..GET PROM ADDRESS.
0138 BC$          0276         PHI MAP
0139 F80F$        0277         LDI 15
013B AC$          0278         PLO MAP
013C D4$          0279         SEP JSR
013D 02F5$        0280         ,A(LKUP) ..GO THROUGH THE LOOKUP ROUTINE.
013F D4$          0281         SEP JSR
0140 04A9$        0282         ,A(RATIO) ..GETS PORTION OF DIFFERENCE.
0142 82$          0283         GLO SP
0143 FC03$        0284         ADI 3
0145 AD$          0285         PLO DAP
0146 FC03$        0286         ADI 3
0148 AC$          0287         PLO MAP
0149 D4$          0288         SEP JSR
014A 0275$        0289         ,A(MLESSD)
014C 82$          0290 CALI:   GLO SP
014D AC$          0291         PLO MAP
014E 1C$          0292         INC MAP
014F F8DA$        0293         LDI RSLT ..ADDRESS TO STORE DATA.
0151 AD$          0294         PLO DAP
0152 D4$          0295         SEP JSR
0153 0585$        0296         ,A(R2DEC) ..CONVERT TO BCD.
0155 09$          0297         ,9 ..NINE DIGITS LONG.
```

```
0156 ;              0299 ..TITLE OF THE ROUTINE IS "STOPE"
0156 ;              0300 ..ROUTINE PUTS DATA FROM AREA PSLT AND PLACES IT IN
0156 ;              0301 ..THE DISPLAY AND IN GPIB BUFFER.
0156 ;              0302 ..ROUTINE DOES NOT SAVE REGISTERS & USES TMP, SCP,
0156 ;              0303 ..DAP AND PAP.  ALSO USES LOCATIONS PSLT, BUFF1 &
0156 ;              0304 ..DPREG.
0156 ;              0305 ..
0156 92:            0306 STOPE: GHI  DP  ..GET UP ADDRESSES.
0157 BE:                        PHI TMP..DAP= TMP POINT TO RAM.
0158 F8E0:          0309        LDI DPREG
015A AE:            0309        PLO TMP ..TMP POINT TO DECIMAL POINT REG.
015B F83C:          0310        LDI #3C
015D A8:            0311        PLO PAP ..MAP POINTS TO DISPLAY IF, DP LOC.
015E 0E:            0312        LDN TMP ..GET DECIMAL POINT VALUE.
015F 58:            0313        STR PAP ..WRITE IT TO INTERFACE.
0160 F837:          0314        LDI #37
0162 A8:            0315        PLO PAP ..POINT TO MSD OF DISPLAY WITH PAP.
0163 0E:            0316        LDN TMP
0164 FA07:          0317        ANI #07 ..MASK DP TO 3 LS BITS,
0166 FD06:          0318        SDI #06 ..8 LESS NUMBER OF DECIMAL PLACES,
0168 AA:            0319        PLO NBR ..LESS ONE MORE FOR SIGN IS DECIMAL
0169 F808:          0320        LDI #08 ..LOCATION COUNTER.
016B AB:            0321        PLO CTR ..CTR IS DIGIT COUNTER.
016C F8FD:          0322        LDI BUFF2
016E AE:            0323        PLO TMP
016F E3:            0324        SEX PC ..SET TO DISABLE INTERRUPTS WHILE
0170 71:            0325        DIS ..STORING DATA IN GPIB BUFFER.
0171 D3:            0326        .=D3 ..SET X=P
0172 0E:            0327        LDN TMP ..# CHARACTERS IN BUFFER.
0173 3277:          0328        BZ LOAD ..IF EMPTY FILL IT.
0175 FF0C:          0329        SMI 12 ..IF UNTOUCHED-
0177 3277:          0330        BZ LOAD ..USE IT FIRST.
0179 F8FC:          0331        LDI BUFF1 ..BUT IF IN USE.
017B AE:            0332        PLO TMP ..USE OTHER BUFFER.
017C 9E:            0333 LOAD:  GLO TMP
017D FF0C:          0334        SMI 12 ..ADJUST ADDRESS
017F AE:            0335        PLO TMP
0180 72:            0336        LDXA    ..GET SIGN, PUT IN BUFF AND INC POIN-
0181 5E:            0337        STR TMP ..TER; ALSO STORE IN NBR.
0182 1E:            0338        INC TMP
0183 BA:            0339        PHI NBR
0184 72:            0340 .TPI:  LDXA    ..GET NEXT DIGIT FROM PSLT.
0185 3A99:          0341        BNZ STRT
0187 8A:            0342        GLO NBR ..TEST DECIMAL LOCATION COUNTER.
0188 3699:          0343        BZ  STRT..BRANCH IF TIME TO STOP ZERO BLANK.
018A 8B:            0344        GLO CTR
018B 32A0:          0345        BZ  TPU
018D F900:          0346        LDI #00 ..LOAD NULLS, STORE IN GPIB BUFFER FOR
018F 5E:            0347        STR TMP ..ZERO.
0190 1E:            0348        INC TMP
0191 FBFF:          0349        XRI #FF ..SET F TO DISPLAY TO BLANK IT,
0193 58:            0350        STR PAP ..DECREMENT AND LOOP AGAIN.
0194 28:            0351        DEC PAP
0195 2B:            0352        DEC CTR ..DEC DIGIT AND DECIMAL COUNTERS.
0196 2A:            0353        DEC NBR
0197 30A4:          0354        BR .TPI ..AND BACK INTO THE LOOP.
0199 52:            0355 STRT:  STR SP  ..SAVE DATA TEMPORARILY.
019A 9A:            0356        GHI NBR ..SHIFT POINTER BACK AND PUT SIGN IN
019B 58:            0357        STR PAP ..BEFORE DIGIT OR LEADING ZERO.
019C 28:            0358        DEC PAP
019D 02:            0359        LDN SP  ..GET DATA BACK.
019E 58:            0360 STPV:  STR PAP
019F 28:            0361        DEC PAP ..STORE DIGITS AND SHIFT POINTER.
01A0 F930:          0362 STPU:  ORI #30 ..FORM ASCII CHARACTERS.
01A2 5E:            0363        STR TMP
01A3 1E:            0364        INC TMP
01A4 8A:            0365        GLO NBR ..CHECK DECIMAL POINT LOCATION.
01A5 3AAB:          0366        BNZ STPW ..IF NOT TO BE ENTERED, BRANCH.
01A7 F62E:          0367        LDI '.' ..LOAD DECIMAL POINT IN ASCII.
01A9 5E:            0368        STR TMP ..PUT IN FOR GPIB, INC POINTER.
01AA 1E:            0369        INC TMP
01AB 2B:            0370 STPW:  DEC CTR ..CHECK DIGIT COUNTER.
01AC 8B:            0371        GLO CTR
01AD 32B3:          0372        BZ  STPX
01AF 2A:            0373        DEC NBR
01B0 72:            0374        LDXA  ..LOAD NEXT DIGIT.
01B1 309E:          0375        BR  STPV ..AND BACK TO STR NEXT DIGIT.
01B3 F80D:          0376 STPX:  LDI CR ..LOAD CR AND LF IN BUFFER FOR GPIB,
01B5 5E:            0377        STR TMP ..AND EXIT ROUTINE.
01B6 1E:            0378        INC TMP
01B7 F80A:          0379        LDI LF
01B9 5E:            0380        STR TMP
01BA F80C:          0381        LDI 12
01BC 1E:            0382        INC TMP
01BD 5E:            0383        STR TMP ..SET NUMBER OF DIGITS = 12.
01BE F8E8:          0384        LDI SPSTAT
01C0 AE:            0385        PLO TMP ..ADDRESS OF SERIAL POLL STAT.
01C1 0E:            0386        LDN TMP
01C2 F980:          0387        ORI #80
01C4 5E:            0388        STR TMP ..SET NEW DATA AVAILABLE.
01C5 E3:            0389        SEX PC
01C6 70:            0390        RET
01C7 23:            0391        .=23 ..X=SP, PC SAME AND IE = 1.
01C8 C00066:        0392 ITEX:  LBR INITLP
01CB ;              0393 ..
01CB ;              0394 ..
01CB ;              0395        END
```

```
01D6 #              0038 ..TITLE IS BCD TO BINARY CONVERSION-
01D6 #              0039 ..ROUTINE CONVERTS BCD NUMBER TO 24 BIT SIGNED BINARY
01D6 #              0040 ..NUMBER ON THE STACK.  ROUTINE CONVERTS AS MANY DIGIT
01D6 #              0041 ..AS ARE SPECIFIED ON AN IN-LINE PARAMETER.
01D6 #              0042 ..IF ADDRESS OF BCD FALLS IN F9XX TO FFXX THEN THE
01D6 #              0043 ..PROGRAM ASSUMES THE MSBIT OF THE MSD IS THE SIGN.
01D6 #              0044 ..CALL IS SEP SCP# .A(DEC2B)# .# LENGTH OF BCD DIGITS.
01D6 #              0045 ..THE ADDRESS OF THE LEAST SIGNIFICANT
01D6 #              0046 ..DIGIT IS IN MAR PRIOR TO ENTRY.
01D6 #              0047 ..MAR IS MODIFIED, SCP IS DESTROYED DURING ROUTINE.
01D6 #              0048 ..RETURNS 2'S COMPLIMENT 3 BYTE WORD ON STACK.
01D6 #              0049 ..
01D6 60#            0050 DEC2B:  IRX  ..RETRIEVE RE-ENTRY FROM STACK AND SAVE
01D7 72#            0051         LDXA ..IN SCP TEMPORARILY.
01D8 BF#            0052         PHI SCP
01D9 F0#            0053         LDX
01DA AF#            0054         PLO SCP
01DB F800#          0055         LDI #00 ..CLEAR 3 BYTES FOR DATA AND PUT RE-
01DD 73#            0056         STXD  ..ENTRY VALUE BACK.
01DE 73#            0057         STXD
01DF 73#            0058         STXD
01E0 9F#            0059         GLO SCP
01E1 73#            0060         STXD
01E2 9F#            0061         GHI SCP
01E3 73#            0062         STXD
01E4 9D#            0063         GHI DAP ..SAVE DAP,TMP,NBR,CTR ON STACK.
01E5 73#            0064         STXD
01E6 8D#            0065         GLO DAP
01E7 73#            0066         STXD
01E8 9E#            0067         GHI TMP
01E9 73#            0068         STXD
01EA 8E#            0069         GLO TMP
01EB 73#            0070         STXD
01EC 9B#            0071         GLO CTR
01ED 73#            0072         STXD
01EE 8A#            0073         GLO NBR
01EF 73#            0074         STXD
01F0 92#            0075         GHI CP ..SET DAP TO POINT TO STORAGE.
01F1 BD#            0076         PHI DAP
01F3 82#            0077         GLO CP
01F3 FC0E#          0078         ADI 11
01F5 AD#            0079         PLO DAP
01F6 F802#          0080         LDI A.1(DECTBL) ..SET TMP TO POINT TO TABLE.
01F8 BE#            0081         PHI TMP
01F9 F8F2#          0082         LDI A.0(DECTBL-1)
01FB AE#            0083         PLO TMP
01FC 4E#            0084         LDA CRP ..GET # OF DIGITS FROM IN-LINE LINK
01FD AA#            0085         PLO NBR ..AND PUT IN NBR LESS ONE FOR SIGN.
01FE 2A#            0086         DEC NBR
01FF F800#          0087         LDI #00
0201 BF#            0088         PHI SCP ..SPACE FOR SIGN LATER.
0202 0C#            0089         LDN MAR ..GET LSD AND ADD INTO RESULT.
0203 2C#            0090         DEC MAR
0204 5D#            0091         STR DAP
0205 2A#            0092 D2BC:   DEC NBR ..ONE LESS DIGIT TO DO.
0206 8A#            0093         GLO NBR
0207 3233#          0094         BZ  D2BA ..IF ALL DONE, BRANCH.
0209 F804#          0095         LDI #04 ..IF NOT SET BIT COUNTER.
020B AB#            0096         PLO CTR
020C 0C#            0097         LDN MAR ..GET NEXT DIGIT
020D 2C#            0098         DEC MAR ..RESET POINTER.
020E F6#            0099 D2BD:   SHR  ..SEE IF THE DECIMAL VALUE IS TO BE ADDED
020F AF#            0100         PLO SCP ..TO THE RESULT.
0210 3B2E#          0101         BNF D2BE ..IF NOT, BRANCH.
0212 ED#            0102         SEX DAP
0213 0E#            0103         LDN TMP ..GET TABLE VALUE AND ADD TO CURRENT
0214 2E#            0104         DEC TMP ..VALUE OF RESULT.
0215 F4#            0105         ADD
0216 73#            0106         STXD
0217 0E#            0107         LDN TMP
0218 2E#            0108         DEC TMP
0219 74#            0109         ADC
021A 73#            0110         STXD
021B 0E#            0111         LDN TMP
021C 2E#            0112         DEC TMP
021D 74#            0113         ADC
021E 73#            0114         STXD
021F 3B24#          0115         BNF D2BX
0221 D7#            0116          SF EPP
0222 0C#            0117         ,DFOVP ..D TO P OVERFLOW CODE.
0223 ED#            0118         SEX DAP ..IN THE EVENT THERE IS A NUMERIC
0224 60#            0119 D2BX:   IRX ..OVERFLOW IN THE CONVERSION.
0225 60#            0120         IRX
0226 60#            0121         IRX ..POINTER MOVED BACK TO RIGHT PLACE.
0227 2B#            0122 D2BE:   DEC CTR
0228 8B#            0123         GLO CTR ..CHECKING IF 4 BITS ARE DONE.
0229 3205#          0124         BZ D2BC ..IF YES, BRANCH.
022B 8F#            0125         GLO SCP ..GET REMAINING DIGIT (SHIFTED).
022C 30DE#          0126         BR D2BD ..AND PROCESS IT.
022E 2E#            0127 D2BB:   DEC TMP ..FAKE POINTER SHIFT IF VALUE NOT
022F 2E#            0128         DEC TMP ..USED IN CONVERSION.
0230 2E#            0129         DEC TMP
0231 3027#          0130         BR D2FE
0233 9C#            0131 D2BA:   GHI MAR
0234 FFF8#          0132          SI #F8
0236 7F55#          0133         ENF D2FF ..IF NOT IN LOOK UP, GO AWAY.
0238 FF04#          0134         SMI #04
023A 3255#          0135         BDF D2FF ..LOOK UP IF 4 X 256 X 4 BITS.
023C 9F#            0136         GHI SCP ..CONTINUE HERE SINCE ADDRESS IS LOOK
023D 3A56#          0137         BNZ D2F6 ..UP UNLESS SIGN IS KNOWN.
023F F803#          0138         LDI #03 ..IF NOT KNOWN, SET BIT COUNT=3 AND
0241 AB#            0139         PLO CTR ..DIGIT COUNTER TO 1.
0242 F801#          0140         LDI #01
0244 AA#            0141         PLO NBR
0245 F82B#          0142         LDI '+'  ..SET SIGN TO + AND STORE IT.
0247 BF#            0143         PHI SCP
0248 0C#            0144         LDN MAR
0249 FA08#          0145         ANI #08
024B 3250#          0146         BZ D2BH ..IF MINUS, CHANGE SIGN.
024D F82D#          0147         LDI '-'
024F BF#            0148         PHI SCP
0250 0C#            0149 D2BH:   LDN MAR
0251 FA07#          0150         ANI #07 ..DATA LESS THE SIGN BIT.
0253 3D0E#          0151         BR D2BD
0255 0C#            0152 D2BF:   LDN MAR ..GET SIGN FROM NORMAL STRING.
0256 FB2B#          0153 D2BG:   XRI '+' ..TEST SIGN.
0258 3246#          0154         BZ D2BJ
025A F803#          0155         LDI #03 ..DO 2'S COMPLIMENT.
025C AB#            0156         PLO CTR
025D F6#            0157         SHR
025E F0#            0158 D2BK:   LDX
025F 7D00#          0159         SDBI #00 ..2'S COMPLIMENT DATA.
0261 73#            0160         STXD
0262 8B#            0161         GLO CTR
0263 9B#            0162         GLO CTR
0264 3A5E#          0163         BNZ D2BK
0266 E2#            0164 D2BJ:   SEX CP ..RESTORE REGISTERS.
0267 60#            0165         IRX
0268 72#            0166         LDXA
0269 AA#            0167         PLO NBR
026A 72#            0168         LDXA
026B AB#            0169         PLO CTR
026C 72#            0170         LDXA
026D AE#            0171         PLO TMP
026E 72#            0172         LDXA
026F BE#            0173         PHI TMP
0270 72#            0174         LDXA
0271 AD#            0175         PLO DAP
0272 F0#            0176         LDX
0273 BD#            0177         PHI DAP
0274 D5#            0178         SEP RTN ..RETURN
```

```
0175 ;                  0177 ..TITLE:  ADD AND SUBTRACT ROUTINES.
0176 ;                  0178 ..THE ROUTINES ADD AND SUBTRACT TWO SIGNED 24 BIT
0177 ;                  0179 ..BINARY NUMBERS.  THE DATA IS POINTED TO BY DAR AND
0178 ;                  0180 ..MAP PRIOR TO ENTRY INTO THE ROUTINES.  THE RESULT
0179 ;                  0181 ..IS PLACED IN (DAR).  ALL OTHER REGISTERS SAVED.
0180 ;                  0182 ..CALL IS SEP JSR; .A(MLESSD) OR A(MPLUSSD)
0181 ;                  0183 ..
0182 ;                  0184 ..
0183 9E;                0185 MLESSD:  GLO CTR ..SAVE CTR VALUE.
0184 73;                0186         STXD
0185 F803;              0187         LDI #03 ..SET BYTE COUNT = 3.
0187 AE;                0188         PLO CTR
0188 ED;                0189         SEX DAR
0189 F4;                0190         SHF ..SET BORROW = 0.
018A F9;                0191 MLDA:   LD  ..GET BYTE OF DATA.
018B 7D00;              0192         SDI #00 ..ZERO - DATA.
018D 73;                0193         STXD
018E 2E;                0194         DEC CTR
018F 8E;                0195         GLO CTR
0190 3A8D;              0196         BNZ MLDA ..LOOP UNTIL ALL DATA COMPLIMENTED.
0192 1A;                0197         IR  ..THEN PUT POINTER BACK AND GO TO ADD.
0193 1A;                0198         IR;
0194 1A;                0199         IR;
0195 C8;                0200         LSKP
0196 9E;                0201 MPLUSD: GLO CTR
0197 73;                0202         STXD
0198 F802;              0203         LDI #02
019A AE;                0204         PLO CTR
019B ED;                0205         SEX DAR
019C FE;                0206         SHL ..SET CARRY = 0.
019D 0C;                0207 MPDA:   LDN MAP ..GET ONE BYTE,
019E 74;                0208         ADC ..(MAR)+(DAR)
019F 73;                0209         STXD ..AND REPLACE.
01A0 2C;                0210         DEC MAP
01A1 2E;                0211         DEC CTR
01A2 8E;                0212         GLO CTR
01A3 3A9F;              0213         BNZ MPDA
01A5 F0;                0214         LDX
01A6 52;                0215         STR SP ..TEMPORARILY STORE.
01A7 0C;                0216         LDN MAP
01A8 74;                0217         ADC
01A9 5D;                0218         STR DAR
01AA 42;                0219         LDA SP ..RETRIEVE D
01AB EC;                0220         SEX MAP
01AC F3;                0221         XOR ..EXCLUSIVE OR (MAR) WITH (DAR)
01AD FE;                0222         SHL ..AND PUT SIGN IN DF TO CHECK FOR
01AE 33A9;              0223         BDF MPDB ..OVERFLOW.
01B0 0D;                0224         LDN DAR
01B1 F3;                0225         XOR ..AND CHECK SIGN OF THE RESULT.
01B2 FE;                0226         SHL
01B3 33A9;              0227         BNF MPDB ..SIGN OF RESULT IS SAME AS OPERAND.
01B5 D7;                0228         SEP ERR
01B6 1C;                0229         ,PMOVP ..NUMERIC OVERFLOW IN ADD/SUB ROUTINE.
01B7 02;                0230 MPDB:   LDN SP ..RETRIEVE REGISTER.
01B8 AE;                0231         PLO CTR
01B9 1D;                0232         INC DAR ..DAR POINTER BACK
01BA 1D;                0233         INC DAR
01BB D5;                0234         SEP RTN
01BC ;                  0235 ..
01BC ;                  0236 ..THIS IS THE CONVERSION TABLE FOR DECIMAL TO B CONV.
01BC 3D09A01E84800F;    0237         .61,2304,30,33920,15,16960,12,13568
01C3 424003500;         0238
01CA 061A8003D4001;     0239         .6,6784,3,3392,1,34464,1,14464,0,40000
01D1 9600013000090;     0240
01D8 400;               0241
01DB 00A2800027100;     0242         .0,20000,0,10000,0,8000,0,4000,0,2000
01E0 1F400003E80000;    0243
01E7 D0;                0244
01E8 0003E8000320005;   0245         .0,1000,0,800,0,400,0,0,200,0,0,100
01EF 0190000C800000;    0246
01F6 640;               0247
01F7 0000500000280005;  0248         .0,0,80,0,0,40,0,0,20,0,0,10
01FE 0014000000;        0249
```

```
02F3 ;                  0244 DECTBL=*
02F3 ;                  0245 ..TITLE OF THE ROUTINE IS LOOKUP.
02F3 ;                  0246 ..THE ROUTINE HANDLES THE LOOKUP TABLE AND ASSOC.
02F3 ;                  0247 ..TASKS.  CALL IS SEP JSR; .A(LKUP).
02F3 ;                  0248 ..MAP IS SET PRIOR TO ENTRY AT LSD OF FIRST LOOKUP
02F3 ;                  0249 ..POINT. DATA USED AS A BASE IS EXPECTED ON THE STACK
02F3 ;                  0250 ..PRIOR TO ENTRY.  LOCATION OF A ZERO VALUE FOR COMP-
02F3 ;                  0251 ..ARISON GENERATES AN ERROR AND EXITS WITH ZERO
02F3 ;                  0252 ..CORRECTION.
02F3 ;                  0253 ..SCR IS DESTROYED, MAP MODIFIED, DAR DESTROYED.
02F3 ;                  0254 ..
02F3 0000;              0255         .=0000 ..BINARY CONSTANT.
02F5 F807;              0256 LKUP:   LDI #07 ..SET A COUNTER IN SCRATCH REG.
02F7 AF;                0257         PLO SCR ..TO CLEAR 7 SPACES FOR WORKING.
02F8 F800;              0258 LKUPA:  LDI #00
02FA 73;                0259         STXD
02FB 2F;                0260         DEC SCR
02FC 8F;                0261         GLO SCR
02FD 3AF8;              0262         BNZ LKUPA ..END OF CLEAR LOOP.
02FF F805;              0263         LDI #05
0301 AF;                0264         PLO SCR ..MOVE FIVE BYTES OF
0302 92;                0265         GHI SP ..DATA DOWN ON THE STACK.
0303 BD;                0266         PHI DAR
0304 82;                0267         GLO SP
0305 FC0C;              0268         ADI 12
0307 AD;                0269         PLO DAR
0308 0D;                0270 LKUPB:  LDN DAR
0309 73;                0271         STXD
030A 2D;                0272         DEC DAR
030B 2F;                0273         DEC SCR
030C 8F;                0274         GLO SCR
030D 3A08;              0275         BNZ LKUPB ..END OF MOVE LOOP.
030F 9C;                0276 LKUPC:  GHI MAP ..
0310 73;                0277         STXD
0311 8C;                0278         GLO MAP
0312 73;                0279         STXD
0313 D4;                0280         SEP JSR
0314 01D6;              0281         .A(DEC2B) ..CONVERT DATA TO BINARY;
0316 07;                0282         .=07 ..SEVEN DIGITS WORTH.
0317 92;                0283         GHI SP ..SET MEMORY POINTER TO NEW DATA,
0318 BC;                0284         PHI MAP ..AND TO ZERO TO SEE IF =0.
0319 82;                0285         GLO SP
031A AC;                0286         PLO MAP
031B 1C;                0287         INC MAP
031C F800;              0288         LDI #00
031E BD;                0289         PHI DAR
031F F84D;              0290         LDI #4D
0321 AD;                0291         PLO DAR
0322 D4;                0292         SEP JSR ..COMPARE VALUES.
0323 03AD;              0293         .A(COMP)
0325 8F;                0294         GLO SCR ..GET RESULT FROM SCRATCH REGISTER.
0326 3293;              0295         BZ LKUPM ..AND BRANCH IF RESULT =0.
0328 82;                0296         GLO SP ..SET ADDRESS OF CORRECTION, AND PUT
0329 FC04;              0297         ADI #04 ..IN MAR.
032B AD;                0298         PLO DAR
032C 92;                0299         GHI SP
032D BD;                0300         PHI DAR
032E 4D;                0301         LDA DAR ..POINTER RETRIEVED FROM STACK
032F FC06;              0302         ADI #06
0331 AC;                0303         PLO MAR
0332 0D;                0304         LDN DAR
0333 7C00;              0305         ADCI #00
0335 BC;                0306         PHI MAR
0336 D4;                0307         SEP JSR ..CONVERT CORRECTION VALUE AND STORE
0337 01D6;              0308         .A(DEC2B) ..ON STACK.
0339 06;                0309         .=06
033A 92;                0310         GHI SP ..SET ADDRESSES FOR COMPARISON.
033B BC;                0311         PHI MAR
033C FD;                0312         PHI DAR
033D 82;                0313         GLO SP
033E FC04;              0314         ADI 4
0340 AC;                0315         PLO MAR ..NEW N DATA POINTER.
0341 FC13;              0316         ADI 19
0343 AD;                0317         PLO DAR ..DATA VALUE POINTER.
0344 D4;                0318         SEP JSR
0345 03AD;              0319         .A(COMP)
0347 8F;                0320         GLO SCR ..RESULTS OF COMPARISON.
0348 FE;                0321         SHL ..IF DATA<INDEX STOP AND FINISH PROCESS.
0349 3264;              0322         BZ LKUPD
```

```
0348 F8nn$          0335          LDI #06 ..IF NOT READY TO STOP,MOVE C AND N
034D AF$            0336          PLO DCR ..DATA INTO WORKSPACE.
034E xx$            0337          GLO DP
034F FCnE$          0338          ADI 14
0351 AC$            0339          PLO MAR
0352 60$            0340          IRX
0353 72$            0341 LKUPE:   LDA A
0354 5C$            0342          STR MAR
0355 1C$            0343          INC MAR
0356 2F$            0344          DEC DCR
0357 9F$            0345          GLO DCR
0358 3A53$          0346          BNZ LKUPE ..END LOOP TO MOVE INTO WORKSPACE.
035A 72$            0347          LDXA  ..SET POINTERS TO NEXT BLOCK  OF
035B FCnD$          0348          ADI 13 ..CORRECTION DATA.
035D AC$            0349          PLO MAR
035E F8$            0350          LDX
0360 xx$            0351          ADCI #nA
0361 BC$            0352          PHI MAR
0362 xxnF$          0353          BR LKUPC
0364 xx$            0354 LKUPD:   GLO SP ..READY TO PROCESS SO CREATE DELTA C.
0365 AC$            0355          PLO MAR ..BY A POINTER TO C1 (MAR) AND C0 (DAR
0366 1C$            0356          INC MAR
0367 1C$            0357          INC MAR
0368 1C$            0358          INC MAR
0369 FC10$          0359          ADI 16
036E AD$            0360          PLO DAR ..(DAR) IS LSBYTE OF C0.
036C D4$            0361          SEP JSR ..PERFORM C1-C0 AND STORES FOR C0.
036D 0375$          0362          .A(MLESSD)
036F xx$            0363          GLO SP
0370 FC0E$          0364          ADI #0E
0372 AC$            0365          PLO MAR ..(MAR) IS LSBYTE OF N1.
0373 FC0D$          0366          ADI 13
0375 AD$            0367          PLO DAR ..DAR IS LSBYTE OF N0.
0376 D4$            0368          SEP JSR ..PERFORMS N1-N0 AND STORE IN N0.
0377 0375$          0369          .A(MLESSD)
0379 $$$            0370          GLO SP
037A FC0E$          0371          ADI #0E
037C AC$            0372          PLO MAR ..(MAR) IS LSBYTE OF N1.
037D FC07$          0373          ADI #07 ..
037F AD$            0374          PLO DAR ..(DAR) IC LSBYTE OF DATA.
0380 D4$            0375          SEP JSR ..PERFORMS N1-D AND STORES IN D.
0381 0375$          0376          .A(MLESSD)
0383 xx$            0377          GLO SP
0384 xx$            0378          PLO MAR
0385 xx$            0379          INC MAR
0386 1C$            0380          INC MAR
0387 1C$            0381          INC MAR
0388 FC19$          0382          ADI 25
038A AD$            0383          PLO DAR ..(DAR) POINTS TO LSBYTE OF DATA.
038B D4$            0384          SEP JSR ..PERFORMS DATA + CORRECTION.
038C 0384$          0385          .A(MPLUSD)
038E 2$             0386          GLO SP
038F FC03$          0387          ADI #03 ..AND STORES IN DATA LOCATION.
0391 AE$            0388          PLO SP ..STACK IS 12 LEVELS DEEP WITH BLANK,
0392 D5$            0389          SEP RTN ..DELTA N, DELTA C, AND N-D.
0393 07$            0390 LKUPM:   SEP ERR
0394 04$            0391          .WINLU ..NOT IN LOOKUP ERROR.
0395 $$$            0392          GLO SP
0396 FC05$          0393          ADI #05 ..SET SP FOR RETURN.
0398 AE$            0394          PLO SP
0399 FCnB$          0395          ADI 11
039B AF$            0396          PLO MAR
039C 9E$            0397          GHI SP
039D BF$            0398          PHI MAR ..SET MAP TO WORKSPACE.
039E F8n9$          0399          LDI #n9 ..CLEAR DELTA C, N MINUS D,
03A0 AF$            0400          PLO DCR ..AND PUT SAME NUMBERS IN DELTA N.
03A1 6F$            0401          RET MAR
03A2 FF06$          0402 LKUPN:   SMI #06
03A4 CF$            0403          LSDF ..SKIP IF NO BORROW.
03A5 F8nn$          0404          LDI #nn
03A7 73$            0405          STXD
03A8 2F$            0406          DEC DCR
03A9 8F$            0407          GLO DCR
03AA 3AA2$          0408          BNZ LKUPN ..EXIT FROM CLEARING ROUTINE.
03AC D5$            0409          SEP RTN
```

```
03AD :              0401 ..TITLE OF ROUTINE IS COMPARE.
03AD :              0402 ..ROUTINE COMPARES TWO 24 BIT NUMBERS AND RETURNS
03AD :              0403 ..WITH DCR (LO)=80 IF (MAP)>(DAR),
03AD :              0404 ..               =01 IF (MAP)<(DAR),
03AD :              0405 ..               =00 IF (MAP)=(DAR)
03AD :              0406 ..CALL IS SEP JSR# ,A(COMP)
03AD :              0407 ..MAP AND DAR SET PRIOR TO ENTRY POINTING TO MSB.
03AD :              0408 ..DATA IS LOWEST ADDRESS=MSB.
03AD :              0409 ..ROUTINE DOES NOT CHECK NUMERIC OVERFLOW!!!
03AD :              0410 ..
03AD E7$            0411 COMP:    SEX MAR
03AE 4D$            0412          LDA DAR
03AF F7$            0413          SM ..DAR-MAR (MSB)
03B0 $0$            0414          IRX
03B1 AF$            0415          PLO SCR ..STORE RESULT OF SUBTRACTION OF MSB.
03B2 4D$            0416          LDA DAR
03B3 F7$            0417          SM ..DAR-MAR (2ND BYTE)
03B4 60$            0418          IRX
03B5 52$            0419          STR SP ..STORE RESULT OF SUBTRACTION.
03B6 8F$            0420          GLO SCR ..RETRIEVE MSB RESULT.
03B7 2$C0$          0421          BZ COMPZ ..BRANCH IF INDETERMINATE COMPARISON.
03B9 FA80$          0422          ANI #80 ..SEE IF MINUS RESULT.
03BB C6$            0423          LSNZ ..SKIP IF IT IS.
03BC F801$          0424          LDI #01 ..PUT 01 IF + RESULT (DAR>MAR)
03BE AF$            0425 COMPA:   PLO SCR ..STORES THE RESULT OF COMARISON.
03BF D5$            0426          SEP RTN ..AND EXIT.
03C0 $$$            0427 COMPZ:   LDN SP ..RETRIEVE SECOND BYTE RESULT.
03C1 3AC7$          0428          BNZ COMPB ..IF UNEQUAL NO NEED TO DO LAST BYTE
03C3 4D$            0429          LDN DAR ..IF EQUAL DO LAST BYTE.
03C4 F7$            0430          SM
03C5 xxFE$          0431          BZ COMPA ..IF LAST IS 0, THEN MAP=DAR
03C7 7E$            0432 COMPB:   SHLC ..CHECK DF TO SEE IF BORROW.
03C8 FA01$          0433          ANI #01
03CA C6$            0434          LSNZ ..IF TRUE, NO BORROW RESULT +.
03CB F880$          0435          LDI #80 ..IF BORROW (MAR>DAR)
03CD 30BE$          0436          BR COMPA
```

```
03CF :              0437 ..
03CF :              0438 ..ROUTINE IS THE CALL AND RETURN.
03CF :              0439 ..CALLS ARE SEP JSR AND SEP RTN.
03CF :              0440 ..BOTH SET THE SP =X
03CF :              0441 ..
03CF D3$            0442 EXITA:   SEP PC ..PC POINTS TO SUBROUTINE.
03D0 E2$            0443 CALL:    SEX SP ..POINT TO STACK AND SAVE LINK REG.
03D1 9B$            0444          GHI LRP
03D2 73$            0445          STXD
03D3 8B$            0446          GLO LRP
03D4 73$            0447          STXD
03D5 93$            0448          GHI PC
03D6 BB$            0449          PHI LRP ..PUT PC TO LINK REG.
03D7 83$            0450          GLO PC
03D8 AB$            0451          PLO LRP
03D9 4B$            0452          LDA LRP ..PICK ADDRESS OF SUBROUTINE.
03DA B3$            0453          PHI PC
03DB 4B$            0454          LDA LRP
03DC A3$            0455          PLO PC
03DD 30CF$          0456          BR EXITA
03DF :              0457 ..
03DF D3$            0458 EXITR:   SEP PC ..PC POINTS TO MAIN PROGRAM.
03E0 9B$            0459 RETPGM:  GHI LRP ..GET MAIN PROGRAM ADDRESS
03E1 B3$            0460          PHI PC ..BACK IN PC.
03E2 8B$            0461          GLO LRP
03E3 A3$            0462          PLO PC
03E4 E2$            0463          SEX SP ..POINT TO STACK AND RETRIEVE OLD LRP.
03E5 12$            0464          INC SP
03E6 72$            0465          LDXA
03E7 AB$            0466          PLO LRP
03E8 F0$            0467          LDX
03E9 BB$            0468          PHI LRP
03EA 30DF$          0469          BR EXITR
```

```
03EC ;          0470 ..TITLE OF ROUTINE IS "PANEL".
03EC ;          0471 ..ROUTINE SERVICES THE FRONT PANEL SWITCHES AND
03EC ;          0472 ..TAKES CARE OF TEST ROUTINE.
03EC ;          0473 ..CALL IS SEP USR1 ;A(PANEL).
03EC ;          0474 ..USES SWSTAT, TESTAT.
03EC ;          0475 ..THIS ROUTINE CALLS SUBROUTINES.
03EC ;          0476 ..
03EC 92$        0477 PANEL:  GHI SP ..SET MAP TO SWSTAT.
03ED BC$        0478         PHI MAP
03EE F8E4$      0479         LDI SWSTAT
03F0 AC$        0480         PLO MAR
03F1 EC$        0481         SEX MAR
03F2 F0$        0482         LDX  ..GET SWITCH STATUS AND SEE IF LLO IS ON.
03F3 FE$        0483         SHL
03F4 33FE$      0484         BDF PNLA ..BRANCH IF LLO IS SET.
03F6 F838$      0485         LDI SWIN  ..IF NOT, SET POINTER TO SW INPUTS.
03F8 A9$        0486         PLO PAR
03F9 09$        0487         LDN PAR ..READ SWITCH INPUTS.
03FA FBFE$      0488         XRI #0F ..INVERT AND OR WITH SWITCH REGISTER.
03FC F1$        0489         OR
03FD 5C$        0490         STR MAR ..AND RETURN THE RESULT TO SWSTAT.
03FE F0$        0491 PNLA:   LDX ..GET STATUS FROM SWSTAT.
03FF FA14$      0492         ANI #04 ..SHOULD RANGE BE CHANGED/
0401 320F$      0493         BZ PNLC ..BRANCH IF NO.
0403 F0$        0494         LDX  ..GET STATUS AGAIN.
0404 FA02$      0495         ANI #02 ..AND IF 1 THEN RANGE IS 10K.
0406 3A08$      0496         BNZ PNLB
0408 F826$      0497         LDI RTEN ..CHANGE RANGE FROM 1 TO 10 K.
040A C8$        0498         LSKP
040B F827$      0499 PNLB:   LDI RONE ..CHANGE RANGE FROM 10 TO 1 K.
040D A9$        0500         PLO PAR
040E 58$        0501         STR PAR ..SELECTS COUNTER RANGE.
040F F0$        0502 PNLC:   LDX  ..GET SWITCH STATUS, CANCEL RANGE CHANGE,
0410 AF$        0503         PLO SCP ..TEST SWITCH AND STORE BACK IN
0411 FAF8$      0504         ANI #F8 ..SWSTAT AGAIN.
0413 5C$        0505         STR MAP
0414 F8E2$      0506         LDI TESTAT ..SEE IF TESTS ARE ON.
0416 AC$        0507         PLO MAR
0417 0C$        0508         LDN MAP
0418 3A25$      0509         BNZ PNLD ..BRANCH IF IN CYCLE.
041A 2F$        0510         GLO SCP
041B FA01$      0511         ANI #01 ..SEE IF TEST SW IS ON.
041D 3263$      0512         BZ  PNLE ..IF NOT, BRANCH TO EXIT,
041F F828$      0513         LDI RTST ..IF SO WRITE TEST TO COUNTER.
0421 A8$        0514         PLO PAP
0422 58$        0515         STR PAR
0423 F810$      0516         LDI 16
0425 FF01$      0517 PNLD:   SMI #01 ..DEC TEST LOOP COUNTER.
0427 5C$        0518         STR MAR
0428 3A63$      0519         BNZ PNLE ..EXIT IF NOT DONE TESTING.
042A 8F$        0520         GLO SCP ..GET SWITCH SETTING.
042B FA01$      0521         ANI #01 ..AND SEE IF TEST IS STILL ON.
042D 325F$      0522         BZ  PNLF
```

```
042F ;          0523 ..TITLE IS MEMORY TEST.
042F ;          0524 ..ROUTINE SUMS ALL ROM AND USES THE RESULT AS DATA.
042F ;          0525 ..DESTROYS MAP, DAP, CTR, SCP LOW.
042F 5C$        0526 MEMTST: STR MAP ..STORES 1 TO ALLOW RECYCLE OF MTST.
0430 F807$      0527         LDI #07 ..COUNTER FOR ALL MEMORY
0432 BE$        0528         PHI CTR
0433 F8FF$      0529         LDI #FF
0435 AE$        0530         PLO CTR
0436 F800$      0531         LDI 0
0438 AC$        0532         PLO MAP ..ADDRESS OF ADDEND =0000.
0439 BC$        0533         PHI MAP
043A AD$        0534         PLO DAP
043B BD$        0535         PHI DAP ..HIGH ORDER SUM =0.
043C AF$        0536         PLO SCP ..AND LOW ORDER SUM.
043D EC$        0537         SEX MAP
043E 8F$        0538 MEMA:   GLO SCP ..GET LOW ORDER SUM.
043F F4$        0539         ADD
0440 AF$        0540         PLO SCP
0441 60$        0541         IRX
0442 3F45$      0542         BNF MEMB ..IF NO CARRY FROM SUM, BRANCH.
0444 1D$        0543         INC DAP ..IF CARRY ADD TO DAP.
0445 2E$        0544 MEMB:   DEC CTR
0446 9E$        0545         GHI CTP ..DOES NOT CHECK OVERFLOW.
0447 3A3E$      0546         BNZ MEMA
0449 8E$        0547         GLO CTP
044A 3A3E$      0548         BNZ MEMA
044C E2$        0549         SEX SP ..DONE WITH LOOP
044D 8F$        0550         GLO SCP
044E 73$        0551         STXD ..PUT DATA ON STACK.
044F 8D$        0552         GLO DAP
0450 73$        0553         STXD
0451 9D$        0554         GHI DAP
0452 73$        0555         STXD
0453 73$        0556         STXD ..FAKE RETURN ADDRESS
0454 73$        0557         STXD
0455 92$        0558         GHI SP
0456 BD$        0559         PHI DAP
0457 BC$        0560         PHI MAP ..RIGHT POINTERS
0458 F801$      0561         LDI A.1(CALI) ..RETURN ADDRESS
045A B6$        0562         PHI LKP
045B F84C$      0563         LDI A.0(CALI)
045D A6$        0564         PLO LKP
045E D5$        0565         SEP RTN
045F F829$      0566 PNLF:   LDI PCLP
0461 A8$        0567         PLO PAP
0462 58$        0568         STR PAP ..WRITE A CLEAR AT END OF TEST
0463 D5$        0569 PNLE:   SEP RTN
0464 ;          0570         END
```

```
0465 ;          0031 ..TITLE IS ERROR
0465 ;          0032 ..ROUTINE HANDLES ERROR CODES FROM IN LINE DATA.
0465 ;          0033 ..WORKS VIA SPSTAT IN RAM, DISABLES INTERRUPTS WHILE
0465 ;          0034 ..CHANGING DATA.  SAVES ALL REGISTERS.
0465 ;          0035 ..CALL IS VIA SEP ERR.
0465 ;          0036 ..ERROR CODE IS IN LINE..
0465 ;          0037 ..SENDS SRQ VIA GPIB IF ON LINE.
0465 ;          0038 ..
0465 D3$        0039         SEP PC
0466 E2$        0040 ERROR:   SEX SP
0467 9D$        0041         GHI DAP ..SAVE REGISTERS
0468 73$        0042         STXD
0469 8D$        0043         GLO DAP
046A 73$        0044         STXD
046B F837$      0045         LDI MSDIG ..MSD OF DISPLAY INTERFACE.
046D A8$        0046         PLO PAR
046E E8$        0047         SEX PAR
046F F80D$      0048         LDI DASH ..CONSTANT FOR DASH
0471 73$        0049         STXD
0472 03$        0050         LDN PC ..GET INLINE ERROR CODE.
0473 F6$        0051         SHR ..ERROR NUMBER /4 TO GET CODE.
0474 F6$        0052         SHR
0475 73$        0053         STXD
0476 F80D$      0054         LDI DASH
0478 73$        0055         STXD
0479 F842$      0056         LDI IBSTAT ..GPIB STATUS REGISTER ADDRESS.
047B A8$        0057         PLO PAR
047C 08$        0058         LDN PAR
```

```
047D 52$          0059          STR SP
047E FA04$        0060          ANI #04 ..CHECK IF ATN IS ON.
0480 3A8C$        0061          BNZ ERPA ..IF ATN TRUE, SPAS IS FALSE -OK
0482 02$          0062          LDN SP ..GET STATUS BACK.
0483 FA08$        0063          ANI #08 ..BRANCH IF ATN IS FALSE AND SPMS
0485 3F8A$        0064          BNZ ERPR ..TRUE SINCE THIS IS SPAS.
0487 02$          0065          LDN SP
0488 FA03$        0066          ANI #03 ..SEE IF TALKER OR LISTENER.
048A 32A0$        0067          BZ ERPB ..NO, SO EXIT.
048C ED$          0068 ERRA:    SEX DAR ..
048D C4$          0069          NOP
048E C4$          0070          NOP
048F F859$        0071          LDI IBSRQ
0491 A8$          0072          PLO PAR
0492 C4$          0073          NOP ..SRQ ADDRESS IN PAR, WAIT.
0493 92$          0074          GHI SP
0494 BD$          0075          PHI DAR
0495 F8E8$        0076          LDI SPSTAT ..LOAD SERIAL POLL STATUS.
0497 AD$          0077          PLO DAR
0498 03$          0078          LDN PC ..GET ERROR CODES.
0499 F1$          0079          OR ..OR WITH CURRENT CODES.
049A F960$        0080          ORI #60 ..AND WITH ERROR CODE ITSELF.
049C 5D$          0081          STR DAR ..AND SAVE IT.
049D 58$          0082          STR PAR ..NOW SET SRQ ON.
049E C4$          0083          NOP
049F C4$          0084          NOP
04A0 E2$          0085 ERRB:    SEX SP
04A1 13$          0086          INC PC
04A2 60$          0087          IRX ..RESET PC AND STACK.
04A3 72$          0088          LDXA ..RESTORE REGISTERS.
04A4 AD$          0089          PLO DAR
04A5 F0$          0090          LDX
04A6 BD$          0091          PHI DAR
04A7 3065$        0092          BR ERROR-1
04A9 $            0093 ..
04A9 $            0094 ..TITLE OF THE ROUTINE IS RATIO.
04A9 $            0095 ..ROUTINE TAKES THE THREE TERM RATIO X*C/N.
04A9 $            0096 ..CALL IS SEP JSR,A(RATIO).
04A9 $            0097 ..DAR,MAR,TMP,SCR,NBR AND CTR ARE MODIFIED.
04A9 $            0098 ..ENTER 3 BYTES OF 0, DENOM, X, C.
04A9 $            0099 ..THE RESULT REPLACES THE 0.
04A9 $            0100 ..
04A9 60$          0101 RATIO:   IRX  ..START BY REARRANGING STACK TO MAKE
04AA 72$          0102          LDXA ..RETURN MUCH SIMPLER.
04AB BE$          0103          PHI TMP ..ALSO GIVES WORKING ROOM.
04AC F0$          0104          LDX
04AD AE$          0105          PLO TMP ..SAVE RETURN ADDRESS IN TMP.
04AE 92$          0106          GHI SP
04AF BD$          0107          PHI DAR
04B0 BC$          0108          PHI MAR ..SET MAR AND DAR TO STACK.
04B1 F809$        0109          LDI 9 ..LOOP TO LOAD NINE BYTES WITH 0'S.
04B3 AB$          0110          PLO CTR
04B4 F800$        0111 RATA:    LDI 0
04B6 73$          0112          STXD
04B7 2B$          0113          DEC CTR
04B8 8B$          0114          GLO CTR
04B9 3AB4$        0115          BNZ RATA ..END OF ZEROING LOOP.
04BB 8E$          0116          GLO TMP ..RETURN THE ADDRESS TO STACK.
04BC 73$          0117          STXD
04BD 9E$          0118          GHI TMP
04BE 73$          0119          STXD
04BF F803$        0120          LDI 3
04C1 BB$          0121          PHI CTR ..SET UP FOR 3 LOOPS OF 3.
04C2 AB$          0122          PLO CTR
04C3 82$          0123          GLO SP
04C4 FC03$        0124          ADI 3
04C6 AC$          0125          PLO MAR ..POINTER TO ZEROES.
04C7 FC09$        0126          ADI 9 ..9+3=12 IS LOCATION OF DATA.
04C9 AD$          0127          PLO DAR ..AND IS IN DAR.
04CA F800$        0128          LDI 0
04CC BA$          0129          PHI NBR ..STORAGE OF RESULTS.
04CD D4$          0130 RATC:    SEP JSR ..COMPARES DATA TO 0.
04CE 03AD$        0131          ,A(COMP)
04D0 8F$          0132          GLO SCR ..RESULT OF COMPARISON IS HERE.
04D1 C20546$      0133          LBZ RATZ ..IF 0 MAKE QUICK EXIT.
04D4 52$          0134          STR SP
04D5 9A$          0135          GHI NBR
04D6 F4$          0136          ADD
04D7 BA$          0137          PHI NBR ..STORE SIGN DATA IN NBR HIGH.
04D8 8F$          0138          GLO SCR
04D9 F6$          0139          SHR
04DA 33DF$        0140          BDF RATB ..DATA IS + SO JUMP AHEAD.
04DC D4$          0141          SEP JSR
04DD 0275$        0142          ,A(MLESSD)
04DF 1D$          0143 RATB:  INC DAR ..POINT TO NEXT DATA GROUP.
04E0 2B$          0144          DEC CTR
04E1 8B$          0145          GLO CTR
04E2 3ACD$        0146          BNZ RATC
04E4 9B$          0147          GHI CTR
04E5 AB$          0148          PLO CTR ..RESETS COUNTER TO 3.
04E6 82$          0149          GLO SP ..POINTER TO MOVE N
04E7 FC0B$        0150          ADI 11
04E9 AC$          0151          PLO MAR
04EA EC$          0152          SEX MAR
04EB 2D$          0153 RATD:  DEC DAR ..MOVES N AND CLEARS AREA.
04EC 0D$          0154          LDN DAR
04ED 73$          0155          STXD
04EE F800$        0156          LDI 0 ..CLEARS AREA FOR SHIFTING C.
04F0 5D$          0157          STR DAR
04F1 2B$          0158          DEC CTR
04F2 8B$          0159          GLO CTR
04F3 3AEB$        0160          BNZ RATD ..END OF LOOP.
04F5 E2$          0161          SEX SP
04F6 1C$          0162          INC MAR
04F7 8C$          0163          GLO MAR
04F8 BE$          0164          PHI TMP ..STORE POINTER TO N=M.
04F9 FC03$        0165          ADI 3
04FB AD$          0166          PLO DAR
04FC AE$          0167          PLO TMP
04FD F817$        0168          LDI 23
04FF AA$          0169          PLO NBR ..VALUE OF SHIFT COUNTER.
0500 D4$          0170 RATH:    SEP JSR
0501 03AD$        0171          ,A(COMP)
0503 8F$          0172          GLO SCR ..GET RESULTS OF COMPARISON.
0504 F6$          0173          SHR
0505 3262$        0174          BZ RATE  ..X>=N
0507 9B$          0175          GHI CTR ..X<N SO SHIFT X LEFT AND C TO PT.
0508 AB$          0176          PLO CTR
0509 FE$          0177          SHL  ..PUT ZEROES IN DF
050A ED$          0178          SEX DAR
050B F0$          0179 RATF:    LDX
050C 7E$          0180          SHLC
050D 73$          0181          STXD
050E 2B$          0182          DEC CTR
050F 8B$          0183          GLO CTR
0510 3A0B$        0184          BNZ RATF ..END OF X2 LOOP.
0512 8E$          0185          GLO TMP
0513 FC03$        0186          ADI 3
0515 AD$          0187          PLO DAR
0516 F806$        0188          LDI 6
0518 AB$          0189          PLO CTR ..6X LOOP.
0519 FE$          0190          SHL ..SETS DF =0.
051A F0$          0191 RATG:    LDX ..GET DATA.
051B 76$          0192          RSHR
051C 5D$          0193          STR DAR
051D 60$          0194          IRX
051E 2B$          0195          DEC CTR
051F 8B$          0196          GLO CTR
0520 3A1A$        0197          BNZ RATG ..END OF DIVIDE BY 2 LOOP.
0522 E2$          0198          SEX SP
0523 8E$          0199          GLO TMP
0524 AD$          0200          PLO DAR
0525 9E$          0201          GHI TMP
0526 AC$          0202          PLO MAR
0527 2A$          0203          DEC NBR
0528 8A$          0204          GLO NBR
0529 3A00$        0205          BNZ RATH
052B 93$          0206          GHI PC
052C BC$          0207          PHI MAR
052D 82$          0208          GLO SP
052E FC06$        0209          ADI 6
0530 AD$          0210          PLO DAR ..ADDRESS LSBYTE-1 OF RESULT,
0531 0D$          0211          LDN DAR ..IF GREATER THAN 1/2, ROUND UP.
0532 2D$          0212          DEC DAR
0533 FE$          0213          SHL
0534 3B3C$        0214          BNF RATW
0536 F861$        0215          LDI A.0(RATE-1)
0538 AC$          0216          PLO MAR
0539 D4$          0217          SEP JSR
053A 0288$        0218          ,A(MPLUSD) ..MPLUS D ADDRESS
053C 9A$          0219 RATK:    GHI NBR
053D FE$          0220          SHL    ..RETRIEVE SIGN DATA.
053E 3B46$        0221          BNF RATZ ..IF NO BIT RESULT IS +.
0540 F85E$        0222          LDI A.0(RATE-4)
0542 AC$          0223          PLO MAR
0543 D4$          0224          SEP JSR
```

```
0544 0275:          0225          .A(MLESSD) ..MLESSDADDRESS.
0546 82:            0226 PATZ:    GLO SP
0547 FC13:          0227          ADI 19 ..POINTS TO STRAGE.
0549 AD:            0228          PLO DAR
054A F805:          0229          LDI 5
054C AE:            0230          PLO CTR
054D 60:            0231          IRX
054E 72:            0232 PATY:    LDXA  ..MOVES DATA BACK.
054F 5D:            0233          STR DAR
0550 1D:            0234          INC DAR
0551 2B:            0235          DEC CTR
0552 8B:            0236          GLO CTR
0553 3A4E:          0237          BNZ PATY
0555 92:            0238          GHI SP
0556 BC:            0239          PHI MAP
0557 82:            0240          GLO SP
0558 FC0C:          0241          ADI 12
055A A2:            0242          PLO SP
055B D5:            0243          SEP RTN
055C :              0244 ..
055C :              0245 ..
055C 000000000001:  0246          .0.0.0.0.0.1
0562 ED:            0247 PATE:SEX SAP
0563 9B:            0248          GHI CTR
0564 AB:            0249          PLO CTR ..3 TIMES LOOP.
0565 F6:            0250          SHP
0566 0C:            0251 PATM:    LDN MAP
0567 75:            0252          SDB
0568 73:            0253          STXD
0569 2C:            0254          DEC MAP
056A 2B:            0255          DEC CTR
056B 8B:            0256          GLO CTR
056C 3A66:          0257          BNZ PATM ..PEPFORMS X MINUS N.
056E 8C:            0258          GLO MAP  ..GET ADDRESS TO C
056F FC0C:          0259          ADI 12
0571 AD:            0260          PLO DAR ..ADDRESS OF C LO BYTE.
0572 F806:          0261          LDI 6
0574 AB:            0262          PLO CTR ..6X LOOP.
0575 F6:            0263          SHR ..CLEAR CARRY.
0576 EC:            0264          SEX MAP
0577 0D:            0265 PATI:    LDN DAP
0578 74:            0266          ADC
0579 73:            0267          STXD
057A 2D:            0268          DEC DAP
057B 2B:            0269          DEC CTR
057C 8B:            0270          GLO CTP
057D 3A77:          0271          BNZ PATI
057F 8E:            0272          GLO TMP
0580 AD:            0273          PLO DAP
0581 9E:            0274          GHI TMP
0582 AC:            0275          PLO MAP
0583 3000:          0276          BR PATH


0585 :              0279 ..TITLE IS BINARY TO BCD CONVERSION.
0585 :              0280 ..ROUTINE CONVERTS 23 BIT 2'S COMPLIMENT NUMBER TO BCD
0585 :              0281 ..AND STORES IT.
0585 :              0282 ..(MAP) POINTS TO MS BYTE OF DATA ON ENTRY.
0585 :              0283 ..(DAP) TO LSD LOCATION IN DECREASING FIELD, LENGTH
0585 :              0284 ..OF THE FIELD IN-LINE FROM CALLING PROGRAM.
0585 :              0285 ..DAR TO SIGN ON EXIT; MAR TO LSBYTE OF DATA.
0585 :              0286 ..CALL IS VIA SEP USR; .A(B2DEC)
0585 :              0287 ..REGISTERS NOT SAVED.
0585 0C:            0288 B2DEC: LDN MAP ..GET DATA MSBYTE.
0586 FE:            0289          SHL ..SEE IF SIGN IS MINUS.
0587 3F9C:          0290          BNF B2DA
0589 EC:            0291          SEX MAR ..POINT TO LSBYTE.
058A 60:            0292          IRX
058B 60:            0293          IRX
058C F0:            0294          LDX ..
058D FD00:          0295          SDI 0 ..0 MINUS DATA
058F 73:            0296          STXD
0590 F0:            0297          LDX
0591 7D00:          0298          SDBI 0 ..0-DATA WITH BORROW.
0593 73:            0299          STXD
0594 F0:            0300          LDX
0595 7D00:          0301          SDBI 0
0597 5C:            0302          STR MAP
0598 E2:            0303          SEX SP
0599 F82D:          0304          LDI "-" ..SET SIGN TO MINUS AFTER COMPL.
059B C8:            0305          LSKP
059C F82B:          0306 B2DA:    LDI "+" ..SET SIGN TO PLUS WHEN PLUS.
059E 73:            0307          STXD ..PUT ON STACK

059F F806:          0308          LDI A.1(BINTBL)
05A1 BE:            0309          PHI TMP
05A2 F830:          0310          LDI A.0(BINTBL-1)
05A4 AE:            0311          PLO TMP
05A5 F807:          0312          LDI 7
05A7 AB:            0313          PLO CTP ..DIGIT COUNTER IS 7.
05A8 1C:            0314          INC MAP
05A9 1C:            0315          INC MAP
05AA :              0316          ..POINTS TO LSBYTE OF DATA.
05AA F800:          0317 B2DB:    LDI 0
05AC AF:            0318          PLO SCR
05AD BB:            0319          PHI CTR ..STORE A ZERO.
05AE F803:          0320          LDI 3 ..LOOP COUNTER VALUE.
05B0 AA:            0321          PLO NBP
05B1 F6:            0322          SHP ..SETS NO BORROW IN DF.
05B2 EE:            0323 B2DC:    SEX TMP
05B3 0C:            0324          LDN MAP ..GETS DATA AND SUBTRACTS.
05B4 2C:            0325          DEC MAP ..THE TABLE VALUE, AND STORES THE
05B5 77:            0326          SMB ..RESULT ON THE STACK.
05B6 E2:            0327          SEX SP
05B7 73:            0328          STXD
05B8 2E:            0329          DEC TMP
05B9 2A:            0330          DEC NBP
05BA 8A:            0331          GLO NBP
05BB 3AB2:          0332          BNZ B2DC
05BD 60:            0333          IRX ..GET RESULT OF SUBTRACTION,
05BE F0:            0334          LDX .. AND THE SIGN IN PARTICULAP.
05BF FE:            0335          SHL
05C0 33E1:          0336          BDF B2DD ..EXIT IF NEGATIVE.
05C2 1F:            0337          INC SCR ..ADD ONE TO DIGIT.
05C3 9B:            0338          GHI CTR
05C4 BA:            0339          PHI NBP
05C5 F803:          0340          LDI 3
05C7 AA:            0341          PLO NBP ..LOOP COUNTER.
05C8 9A:            0342 B2DE:    GHI NBP
05C9 F1:            0343          OP
05CA BA:            0344          PHI NBP
05CB 72:            0345          LDXA ..GET RESULT
05CC 1C:            0346          INC MAP
05CD 5C:            0347          STR MAP ..AND REPLACE DATA WITH RESULT.
05CE 1E:            0348          INC TMP
05CF 2A:            0349          DEC NBP ..CHECK LOOP COUNTER.
05D0 8A:            0350          GLO NBP
05D1 3AC8:          0351          BNZ B2DE
05D3 22:            0352          DEC SP
05D4 9A:            0353          GHI NBP
05D5 CE:            0354          LSZ ..DATA = 0 TAKE A SHORTCUT.
05D6 30AE:          0355          BR B2DB+4
05D8 8F:            0356          GLO SCR
05D9 73:            0357 B2DF:    STXD
05DA 2B:            0358          DEC CTR ..STORE REMAINING DIGITS.
05DB 8B:            0359          GLO CTR ..AS ZEROS TO SPEED UP.
05DC 32F6:          0360          BZ B2DK
05DE 9B:            0361          GHI CTP
05DF 30D9:          0362          BR B2DF
05E1 60:            0363 B2DD:    IRX ..CHANGE DIGIT POINTER TO RIGHT LOCATION
05E2 60:            0364          IRX ..GET VALUE OF DIGIT AND MAKE SURE IT IS
05E3 8F:            0365          GLO SCR ..LESS THAN 9.
05E4 FD09:          0366          SDI 9
05E6 33ED:          0367          BPZ B2DG
05E8 D7:            0368          SEP ERR ..DISPLAY "3".
05E9 0C:            0369          .BDOVP ..CONVERSION OVERFLOW.
05EA F809:          0370          LDI 9
05EC 38:            0371          SKP
05ED 8F:            0372 B2DG:    GLO SCP
05EE 73:            0373          STXD
05EF 1C:            0374          INC MAR  ..RESET THE DATA POINTERS.
05F0 1C:            0375          INC MAR
05F1 1C:            0376          INC MAP
05F2 2B:            0377          DEC CTP
05F3 8B:            0378          GLO CTR
05F4 3AAA:          0379          BNZ B2DB ..DIGIT COUNTER NOT ZERO.
05F6 46:            0380 B2DK:    LDA LKR ..GET IN LINE LENGTH.
05F7 AB:            0381          PLO CTR
05F8 2B:            0382          DEC CTR ..LESS ONE FOR SIGN.
05F9 F807:          0383          LDI 7
05FB AA:            0384          PLO NBP ..MAX NUMBER OF DIGITS FOR 23  BITS.
05FC ED:            0385          SEX DAP
05FD 12:            0386          INC SP
05FE 42:            0387 B2DL:    LDA SP
05FF 73:            0388          STXD ..GETDIGIT AND PUT IN DATA LOCATION.
0600 2A:            0389          DEC NBP ..ONE LESS DIGIT.
```

```
0601 2B$              0390          DEC CTR
0602 8B$              0391          GLO CTR
0603 3210$            0392          BZ B2DN ..IF OUT OF DIGITS.
0605 8A$              0393          GLO NBR ..STORE DIGITS UNTIL COUNTER DONE,
0606 CA05FE$          0394          LBNZ B2DL ..THEN PAD ZEROS UNTIL LENGTH FILLED.
0609 22$              0395          DEC SP
060A 9B$              0396          GHI CTR
060B 52$              0397          STR SP
060C 1A$              0398          INC NBR
060D C005FE$          0399          LBR B2DL
0610 8A$              0400 B2DN:    GLO NBP
0611 3219$            0401          BZ B2DM ..DIGIT COUNTER DONE, IF NOT
0613 D7$              0402          SEP ERR ..SEND ERROR OF "5"
0614 14$              0403          ,BDTRC ..TRUNCATION OF RESULT.
0615 12$              0404          INC SP
0616 2A$              0405          DEC NBR ..LOOP UNTIL DIGITS ARE DONE
0617 3010$            0406          BR B2DN
0619 02$              0407 B2DM:    LDN SP ..RETRIEVE SIGN
061A 5D$              0408          STR DAR ..AND STORE IT.
061B D5$              0409          SEP RTN ..RETURN TO CALLER.
061C 0000010000A00$   0410 ,0,0,1,0,0,10,0,0,100,0,1000,0,10000,1,34464
0623 00640003E80027$  0410
062A 100186A0$        0410
062E 0F4240$          0411 ,15,16960


0631 $                0057 ..TITLE OF ROUTINE IS GPIB SERVICE.
0631 $                0058 ..ROUTINE SERVICES INTERRUPTS FROM THE GPIB INTERFACE
0631 $                0059 ..AND HANDLES THE DATA TRANSFERS.  THERE ARE TWO
0631 $                0060 ..EXIT POINTS; ONE IS THE NORMAL AND THE SECOND IS IF
0631 $                0061 ..THE DOUBLE BUFFERED DATA IS EMPTY.  THE ROUTINE
0631 $                0062 ..EXITS WITHOUT ALLOWING INTERRUPTS WHEN THIS OCCURS
0631 $                0063 ..TO ALLOW REFILLING THE DATA.
0631 $                0064 ..ONLY ENTRY IS VIA AN INTERRUPT.  ALL REGISTERS ETC
0631 $                0065 ..ARE SAVED EXCEPT WHEN COMMAND OF DEVICE CLEAR IS
0631 $                0066 ..GIVEN.  NOTHING IS SAVED WHEN THIS HAPPENS.
0631 $                0067 ..
0631 92$              0068 SERVIC: GHI SP ..DATA LOCATIONS.
0632 BD$              0069          PHI DAR
0633 F841$            0070          LDI IBINT ..SET UP ADDRESS OF INTERRUPT SOURCE.
0635 A8$              0071          PLO PAR
0636 08$              0072          LDN PAR
0637 FB0F$            0073          XRI #0F ..CHANGE SIGNS OF SOURCES.
0639 FA0F$            0074          ANI #0F ..AND MASK OTHER BITS.
063B C207AE$          0075          LBZ RTLSW ..ONLY INTERRUPT IS RTL MANUAL.
063E F6$              0076          SHR
063F BF$              0077          PHI SCR ..GET LOWEST AND SAVE REMAINDER.
0640 C207350$         0078          LBNF ANPINT ..INTERRUPT WAS NOT ACDS, BRANCH.
0643 28$              0079          DEC PAR ..PAR POINTS TO DATA.
0644 4A$              0080          LDA PAR
0645 AF$              0081          PLO SCR ..GET DATA, SAVE IN SCRATCH REGISTER.
0646 18$              0082          INC PAR ..GET GPIB STATUS TO SEE IF ATN IS ON.
0647 08$              0083          LDN PAR
0648 FA04$            0084          ANI #04
064A 3AA2$            0085          BNZ LIST3 ..IF ATN IS ON BRANCH TO LIST3.
064C 08$              0086          LDN PAR ..READ STATUS AGAIN AND
064D F6$              0087          SHR ..SEE IF LISTENER ADDRESS STATE IS TRUE.
064E 335F$            0088          BDF ZERO
0650 D7$              0089          SEP ERR ..SEND BUSS ERROR (LOGIC).
0651 01$              0090          ,#01 ..DISPLAYS "0"
0652 C8$              0091          LSKP
0653 A8$              0092          PLO PAR
0654 58$              0093          STR PAR
0655 38$              0094          SKP
0656 5D$              0095          STR DAR
0657 F857$            0096 LIST5:   LDI IBCLRY ..CLEAR READY FOR DATA.
0659 A8$              0097          PLO PAR
065A 58$              0098          STR PAR
065B 9F$              0099          GHI SCR ..TEST FOR OTHER INTERRUPT SOURCES.
065C C00735$          0100          LBR ANPINT
065F 8F$              0101 ZERO:    GLO SCR
0660 FB5A$            0102          XRI T'Z' ..SEE IF DATA IS ZERO COMMAND.
0662 3A6C$            0103          BNZ HIGH ..BRANCH IF NO.
0664 F8E4$            0104          LDI SWSTAT ..IF YES, SET ZERO COMMAND IN SWST
0666 AD$              0105          PLO DAR ..SO THAT IT WILL BE DONE NEXT PASS.
0667 0D$              0106          LDN DAR
0668 F908$            0107          ORI #08 ..OR WITH OTHER DATA IN SWSTAT.
066A 3056$            0108          BR LIST5-1
066C F8E4$            0109 HIGH:    LDI SWSTAT ..LOAD STATUS REGISTER ADDR.
066E AD$              0110          PLO DAR
066F 8F$              0111          GLO SCR

0670 FB48$            0112          XRI T'H' ..SEE IF HIGH RANGE TO BE SELECTED.
0672 3A80$            0113          BNZ LOW ..IF NO GO TO LIST7.
0674 ED$              0114          SEX DAR
0675 F8F9$            0115          LDI #F9 ..MASK FOR RANGE BITS.
0677 F2$              0116          AND ..APPLY THE MASK.
0678 5D$              0117          STR DAR ..STORE RESULT OF MASK.
0679 F804$            0118          LDI #04 ..BIT PATTERN FOR HIGH.
067B ED$              0119 LIST8:   SEX DAR
067C F1$              0120          OR ..OR BIT PATTERN IN STATUS REGISTER.
067D E2$              0121          SEX SP
067E 3056$            0122          BR LIST5-1 ..GO REPLACE DATA IN REGISTER.
0680 8F$              0123 LOW:   GLO SCR
0681 FB4C$            0124          XRI T'L' ..SEE IF LOW RANGE TO BE SELECTED.
0683 3A89$            0125          BNZ TEST ..IF NO GO TO TEST.
0685 F806$            0126          LDI #06  ..BIT PATTERN FOR LOW.
0687 307B$            0127          BR LIST8 ..SAME WAY AS HIGH RANGE.
0689 8F$              0128 TEST:  GLO SCR
068A FB54$            0129          XRI T'T' ..SEE IF TEST WAS PUSHED.
068C 329A$            0130          BZ LIST12 ..IF NO, CONTINUE TO MEMRY.
068E 8F$              0131 MEMRY: GLO SCR
068F FB4D$            0132          XRI T'M' ..SEE IF MEMORY TEST IS TO BE.
0691 3A57$            0133          BNZ LIST5 ..IF NOT,GO OUT OF ROUTINE.
0693 F8E4$            0134          LDI SWSTAT ..GET SWITCH STATUS,
0695 AD$              0135          PLO DAR
0696 0D$              0136          LDN DAR
0697 F901$            0137          ORI #01 ..SET TEST SWITCH TO ON.
0699 5D$              0138          STR DAR   ..AS IF END OF TEST WITH BUTTON
069A $                0139                    ..STILL PUSHED, WHICH IS TEST COND.
069A F8E2$            0140 LIST12: LDI TESTAT ..GET TEST STATUS.
069C AD$              0141          PLO DAR
069D 8F$              0142          GLO SCR
069E FA11$            0143          ANI #11 ..GIVES 16 IF TEST, 1 IF MEMORY TEST.
06A0 3056$            0144          BR LIST5-1 ..EXIT POINT.
06A2 8F$              0145 LIST3:   GLO SCR ..IF ATN IS ON, PROGRAM COMES HERE.
06A3 FB01$            0146          XRI MGTL ..CHECKS GO TO LOCAL COMMAND.
06A5 3AB4$            0147          BNZ LCLLO  ..IF NO, JUMP AHEAD.
06A7 F8E4$            0148          LDI SWSTAT ..IF YES, CLEAR LOCKOUTS.
06A9 AD$              0149          PLO DAR
06AA 0D$              0150          LDN DAR
06AB FE$              0151          SHL
06AC F6$              0152          SHR ..CLEARS MSBIT, WHICH IS LOCKOUT BIT.
06AD 5D$              0153          STR DAR
06AE 1D$              0154          INC DAR ..POINTS TO LOSREG.
06AF 0D$              0155          LDN DAR
06B0 F6$              0156          SHR
06B1 FE$              0157          SHL ..CLEARS LSBIT, WHICH IS LOCKOUT BIT.
06B2 3056$            0158          BR LIST5-1 ..AND EXIT.
06B4 8F$              0159 LCLLO: GLO SCR
06B5 FB11$            0160          XRI MLLO ..CHECK FOR LLO CHARACTER.
06B7 3AC6$            0161          BNZ SEPPE  ..IF NO, JUMP AHEAD.
06B9 9F$              0162          GHI SCR
06BA FA04$            0163          ANI #04 ..(NUMBER TESTED IS SHIFTED).
06BC 3257$            0164          BZ LIST5 ..IF RESULT IS 1 THEN REN IS SET.
06BE F8E3$            0165          LDI LOSREG ..LOCKOUT STATE REGISTER.
06C0 AD$              0166          PLO DAR
06C1 0D$              0167          LDN DAR ..SET LOCAL OR REMOTE WITH LOCKOUT.
06C2 F902$            0168          ORI #02
06C4 3056$            0169          BR LIST5-1
06C6 8F$              0170 SEPPE: GLO SCR
06C7 FB18$            0171          XRI MSPE ..IS SERIAL POLL ENABLE SET?
06C9 3ACF$            0172          BNZ SEPPD ..IF NO, JUMP AHEAD.
06CB F85B$            0173          LDI IBSPMS ..WRITE SPMS IN GPIB INTERFACE.
06CD 3053$            0174          BR LIST5-4
06CF 8F$              0175 SEPPD: GLO SCR
06D0 FB19$            0176          XRI MSPD ..IS SERIAL POLL DISABLE SET?
06D2 3AD8$            0177          BNZ ULGRP ..IF NO,JUMP AHEAD
06D4 F853$            0178          LDI IBCLSP  ..WRITE CLEAR SERIAL POLL STATE.
06D6 3053$            0179          BR LIST5-4
06D8 8F$              0180 ULGRP: GLO SCR
06D9 FA20$            0181          ANI MULG ..TESTS UNIVERSAL LISTEN GROUP.
06DB C2070B$          0182          LBZ UTGRP ..IF NO, JUMP AHEAD.
06DE 8F$              0183          GLO SCR
06DF FB3F$            0184          XRI MUNLC ..TEST FOR UNLISTEN COMMAND.
06E1 3AE7$            0185          BNZ MLADDR ..IF NO,JUMP AHEAD.
06E3 F856$            0186          LDI IBCLML ..WRITE CLEAR LISTENER ADDR STATE.
06E5 3053$            0187          BR LIST5-4
06E7 F843$            0188 MLADDR:  LDI IBMLA
06E9 A8$              0189          PLO PAR
06EA 8F$              0190          GLO SCR
06EB E8$              0191          SEX PAR
06EC F3$              0192          XOR ..COMPARES DATA WITH MY LISTEN ADDRESS.
06ED E2$              0193          SEX SP
```

```
06EE 3A57$          0194          BNZ LIST5 ..IF NOT MINE, EXIT.
06F0 F855$          0195          LDI IBCLMT ..IF MINE, CLEAR TALK ADDRESS STATE.
06F2 A8$            0196          PLO PAR
06F3 58$            0197          STR PAR
06F4 F85E$          0198          LDI IBMLAS
06F6 A8$            0199          PLO PAR
06F7 58$            0200          STR PAR ..SET LISTENER ADDRESS STATE.
06F8 9F$            0201          GHI SCR ..GET INTERRUPT SOURCE,
06F9 $              0202          ..NOW A LISTENER, ALSO CHECK REMOTE ENABLE
06F9 $              0203          $..CONDITION BEFORE PROCEEDING.
06F9 FA04$          0204          ANI #04
06FB 3A57$          0205          BNZ LIST5 ..IF REN NOT SET, EXIT.
06FD F8E5$          0206          LDI LOSREG
06FF AD$            0207          PLO DAR
0700 0D$            0208          LDN DAR
0701 F901$          0209          ORI #01
0703 5D$            0210          STR DAR ..SET TO REMOTE W OR WO LOCKOUT.
0704 2D$            0211          DEC DAR
0705 0D$            0212          LDN DAR ..GET SWSTAT
0706 F980$          0213          ORI #80 ..SET LOCKOUT IN SW STAT.
0708 C00656$        0214          LBR LIST5-1
070B 8F$            0215 UTGRP: GLO SCR
070C FA40$          0216          ANI MUTG ..TEST FOR UNIVERSAL TALK GROUP.
070E 322A$          0217          BZ DVCLR ..IF NO, JUMP AHEAD.
0710 8F$            0218          GLO SCR
0711 FB5F$          0219          XRI MUNTC ..TEST FOR UNTALK COMMAND.
0713 3225$          0220          BZ MTADDR ..CLEAR IF UNTALK.
0715 F844$          0221          LDI IBMTA
0717 A8$            0222          PLO PAR ..ADDRESS OF MY TALK ADDRESS.
0718 8F$            0223          GLO SCR
0719 E8$            0224          SEX PAR
071A F3$            0225          XOR
071B E2$            0226          SEX SP
071C 3A25$          0227          BNZ MTADDR ..CLEAR IF OTHER TALK ADDRESS.
071E F85D$          0228 OTADDP:  LDI IBMTAS
0720 A8$            0229          PLO PAR
0721 59$            0230          STR PAR
0722 F856$          0231          LDI IBCLML ..STORE TALKER ADDRESS STATE, CLEAR
0724 C8$            0232          LSKP..LISTENER ADDRESS STATE.
0725 F855$          0233 MTADDR: LDI IBCLMT ..CLEAR TALKER ADDRESS STATE.
0727 C00653$        0234 L5:      LBR LIST5-4 ..AND EXIT.
072A 8F$            0235 DVCLR: GLO SCR
072B FB14$          0236          XRI MDCL ..TEST FOR DEVICE CLEAR?
072D 3A32$          0237          BNZ PT ..IF NOT, BRANCH TO EXIT.
072F F8BD$          0238          LDI A.0(CLVEC) ..SET ADDRESS OF ADDRESS FOR
0731 A1$            0239          PLO IV ..CLEARING OF UNIT.
0732 C00657$        0240 PT:    LBR LIST5
0735 F85F$          0241 ANRINT: LDI IBRFD
0737 A8$            0242          PLO PAR
0738 58$            0243          STR PAR ..SET READY FOR DATA.
0739 9F$            0244          GHI SCR
073A 32BC$          0245          BZ EXC ..IF NO OTHER SOURCE OF INTERRUPTS.
073C F4$            0246 DACINT:  SHR ..SEE IF DAC WAS INTERRUPT SOURCE.
073D F4$            0247          SHR
073E 1F$            0248          PHI SCR
073F 3B44$          0249          BNF RENINT ..IF NOT, JUMP AHEAD.
0741 F850$          0250          LDI IBNRA
0743 A8$            0251          PLO PAR ..CLEAR NEW BYTE AVAILABLE.
0744 58$            0252          STR PAR
0745 F848$          0253          LDI IBSTAT
0747 A8$            0254          PLO PAR
0748 08$            0255          LDN PAR ..GET STATUS OF GPIB.
0749 FA09$          0256          ANI #09 ..TEST FOR SERIAL POLL.
074B 3A5E$          0257          BZ TLK54 ..IF NOT JUMP AHEAD.
074D F8E3$          0258          LDI SPSTAT ..IF SERIAL POLL GET DATA ADDRESS.
074F A8$            0259          PLO DAR
0750 F840$          0260          LDI IBDATA
0752 A8$            0261          PLO PAR ..STORAGE ADDRESS.
0753 0D$            0262          LDN DAR ..GET DATA AND STORE ON BUSS.
0754 59$            0263          STR PAR
0755 F800$          0264          LDI #00
0757 5D$            0265          STR DAR ..CLEAR DATA SOURCE.
0758 F851$          0266          LDI IBCLR0
075A A8$            0267          PLO PAR
075B 58$            0268          STR PAR ..CLEAR REQUEST FOR SERVICE.
075C 3B5E$          0269          BF TLK55
075E F8EC$          0270 TLK54: LDI BUFF1
0760 A8$            0271          PLO DAR
0761 0D$            0272          LDN DAR ..# OF CHARACTERS LEFT.
0762 59$            0273          STR SP ..TEMPORARILY SAVE.
0763 AE$            0274          PLO CTR ..
0764 F8CD$          0275          LDI BUFF2
```

```
0766 AD$            0276          PLO DAR
0767 0D$            0277          LDN DAR
0768 F4$            0278          ADD  ..SUM OF CHARACTERS AVAILABLE.
0769 3A70$          0279          BNZ TLK59 ..IF NOT ZERO, SOME CHARACTERS.
076B D7$            0280          SEP ERR ..BOTH EMPTY SO SET ERROR.
076C 10$            0281          ,DATERR
076D 7B$            0282          SEQ ..SET FLAG FOR NO INTERRUPT EXIT.
076E 309F$          0283          BR TLK55
0770 52$            0284 TLK59:   STR SP ..SAVE SUM OF CHARACTERS.
0771 0D$            0285          LDN DAR
0772 327F$          0286          BZ TLK58 ..BUFF2 EMPTY, USE #1.
0774 FF0C$          0287          SMI 12
0776 3A82$          0288          BNZ TLKR ..IF NOT ZERO, BUFF2 IN USE.
0778 8B$            0289          GLO CTR
0779 3282$          0290          BZ TLKR ..BUFF2 FULL, BUFF1 EMPTY.
077B FF0C$          0291          SMI 12
077D 3282$          0292          BZ TLKR .. BUFF2 AND BUFF1 FULL, USE BUFF2.
077F F8BC$          0293 TLK58:   LDI BUFF1
0781 AD$            0294          PLO DAR
0782 0D$            0295 TLKR:    LDN DAR
0783 AB$            0296          PLO CTR
0784 2B$            0297          DEC CTR
0785 8B$            0298          GLO CTR
0786 5D$            0299          STR DAR ..RETURN DECREMENTED COUNT.
0787 3A91$          0300          BNZ TLK52 ..NOT LAST CHARACTER IN BUFFER.
0789 02$            0301          LDN SP ..IF LAST CHARACTER,
078A F6$            0302          SHR
078B C6$            0303          LSNZ ..BUT OTHERS IN OTHER BUFFER.
078C 7B$            0304          SEQ ..BUT IF LAST IN BOTH,
078D C4$            0305          NOP ..DONT ALLOW INTERRUPTS.
078E F85A$          0306          LDI IBEOI
0790 C8$            0307          LSKP
0791 F852$          0308 TLK52:   LDI IBCLEI ..CLEARS EOI.
0793 A8$            0309          PLO PAR
0794 58$            0310          STR PAR
0795 2D$            0311 TLK56:   DEC DAR
0796 8B$            0312          GLO CTR
0797 2B$            0313          DEC CTR
0798 3A95$          0314          BNZ TLK56
079A F840$          0315          LDI IBDATA ..STORAGE ON BUSS
079C A8$            0316          PLO PAR
079D 0D$            0317          LDN DAR
079E 58$            0318          STR PAR
079F F858$          0319 TLK55:   LDI IBCLNB
07A1 A8$            0320          PLO PAR
07A2 58$            0321          STR PAR ..WRITE NBA TO BUSS
07A3 9F$            0322          GHI SCR
07A4 32BC$          0323 RENINT:  BZ EXC
07A6 F8E5$          0324          LDI LOSREG ..REN INTERPUPT MEANS REN LINE
07A8 AD$            0325          PLO DAR ..IS OFF SO RETURN TO LOCAL.
07A9 F800$          0326          LDI #00
07AB 5D$            0327          STR DAR
07AC 30B5$          0328          BR CLRLLO
07AE F8E5$          0329 RTLSW:   LDI LOSREG
07B0 AD$            0330          PLO DAR
07B1 0D$            0331          LDN DAR ..GET LOCKOUT STATE REGISTER.
07B2 F6$            0332          SHR ..TEST IF LOCKOUT STATE.
07B3 3ABC$          0333          BNZ EXC ..IF NOT LOCKED OUT CONTINUE.
07B5 F8E4$          0334 CLRLLO:  LDI SWSTAT
07B7 AD$            0335          PLO DAR
07B8 0D$            0336          LDN DAR ..GET SWITCH STATUS.
07B9 FE$            0337          SHL
07BA F6$            0338          SHR ..CLEAR LLO SINCE RTL SWITCH IS ASSUM
07BB 5D$            0339          STR DAR ..ED TO BE THE SOURCE.
07BC D1$            0340 EXC:     SEP IV ..IF LOCKED OUT.
07BD F800$          0341 CLVEC:   LDI A.1(START)
07BF B3$            0342          PHI PC
07C0 F80D$          0343          LDI A.0(START)
07C2 A3$            0344          PLO PC
07C3 D3$            0345 EXITA:   SEP PC
07C4 60$            0346          IRX ..THIS I EXIT ROUTINE.
07C5 72$            0347          LDXA
07C6 F6$            0348          SHR
07C7 BB$            0349          PHI CTR
07C8 72$            0350          LDXA
07C9 AB$            0351          PLO CTR
07CA 72$            0352          LDXA
07CB BD$            0353          PHI DAR
07CC 72$            0354          LDXA
07CD AD$            0355          PLO DAR
07CE 72$            0356          LDXA
07CF A8$            0357          PLO PAR
```

```
07D0 72:          0358          LDXA
07D1 BF:          0359          PHI SCP
07D2 72:          0360          LDXA
07D3 AF:          0361          PLO SCP
07D4 72:          0362          LDXA
07D5 B3:          0363          PHI PC
07D6 72:          0364          LDXA
07D7 A3:          0365          PLO PC
07D8 72:          0366          LDXA ..THIS RETURNS D.
07D9 39DD:        0367          BNQ IBSRV-1 ..FOR NORMAL RETURN.
07DB 71:          0368          DIS ..IF RETURN WITHOUT INTERRUPTS.
07DC 38:          0369          SKP
07DD 70:          0370          RET ..RETURNS WITH INTERRUPTS ENABLED..
07DE 22:          0371 IBSRV:   DEC SP ..MAKE ONE POSITION FOR SAFETY.
07DF 78:          0372          SAV ..THEN PUSH T, D AND REGISTERS ON STACK.
07E0 22:          0373          DEC SP
07E1 73:          0374          STXD
07E2 83:          0375          GLO PC
07E3 73:          0376          STXD
07E4 93:          0377          GHI PC
07E5 73:          0378          STXD
07E6 F806:        0379          LDI A.1(SERVIC)
07E8 B3:          0380          PHI PC
07E9 F831:        0381          LDI A.0(SERVIC)
07EB A3:          0382          PLO PC
07EC 8F:          0383          GLO SCP
07ED 73:          0384          STXD
07EE 9F:          0385          GHI SCP
07EF 73:          0386          STXD
07F0 88:          0387          GLO DAP
07F1 73:          0388          STXD
07F2 8D:          0389          GLO DAP
07F3 73:          0390          STXD
07F4 9D:          0391          GHI DAP
07F5 73:          0392          STXD
07F6 8B:          0393          GLO CTR
07F7 73:          0394          STXD
07F8 7A:          0395          REQ ..RESET Q BEFORE ENTRY.
07F9 9B:          0396          GHI CTR
07FA 7E:          0397          SHLC ..SAVES CARRY BIT.
07FB 73:          0398          STXD
07FC 30C3:        0399          BR EXITA
07FE :            0400          END
```

MP MASTER
MA21892